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THE LATE ORDNANCE COMMITTEE.

Written for Van Nostrand's Magazine.

By the two reports of the Select Committee on Ordnance, submitted to Congress July 17th. 1868 and Feb. 15th, 1869, the Ordnance Departments of the Army and Navy have been subjected to great reproach. In addition to charges seriously compromising the official integrity of certain officers, the whole service has been sweepingly condemned as incompetent and unqualified, persistently adherent to false practice and theory, and impervious to improvement. Its abolition is recommended, with the substitution of a board composed of officers and civilians. Knowing the causes which led to these investigations and reports, and having some knowledge of the persons who procured the appointment of the committee, and of their motives and antecedents, we have deemed it proper to lay before the public, so far as we may, a review of the whole matter. It need hardly be said that the subject is an important one, relating as it does to a most essential branch of the executive department of government, and the one charged with providing materials of national defense.

The report of July 17th, 1868, received considerable notice through various newspapers, and is already known to the public. It related, almost exclusively, to the action of the Chief of Ordnance in the purchase of rifle projectiles. The other report has received less public notice, although it was more sweeping in character and significant in language, being nothing less than a general arraignment and condemnation of the Ordnance Department in the strongest terms. We have deemed it proper to discuss the two reports separately, and analyze them in detail.

Fortunately, we are able to decline entering into any examination looking to the refutation of the charges contained in the first report, since this has been done most satisfactorily by the court of inquiry, summoned at the request of the officer whose record had been assailed. The charges made by the committee are not only met, in the finding of the court, by a flat denial, but are virtually pronounced to be utterly without foundation in facts, and the accused is directly complimented for his integrity and efficiency. The characters of the officers constituting the court will certainly place its finding beyond cavil on the ground of partiality or bias, or any ulterior motive, while the exhaustive investigation, extending over six months of almost uninterrupted session, and conducted by able and expert counsel on both sides, to whom was allotted the largest liberty in respect to the range of testimony, will be a good guarantee of completeness and accuracy.

In comparing the findings of the court and of the committee, we first note the fact that the evidence, upon which the charges rested, was substantially the same before both. The same witnesses were summoned for the prosecution before the court as appeared in the committee room, and reiterated their statements; the documentary evidence in the two examinations differed only in being much more complete at the second than at the first. It may then be fairly asked, how happens it that the two bodies arrived at

diametrically opposite conclusions? If there had been evidence enough before the committee to procure such a strong condemnation as was actually delivered, the same evidence before the court ought to have, at least, qualified the acquittal. It will be borne in mind that the diversity of opinion was upon matters of simple fact and not of law. Had it been the former, it might readily be passed over as an ordinary difference of opinion upon a matter of principle, illustrating two ways of viewing the same thing, and both defensible; but in truth each body was called upon to report facts, and these are matters such as the law holds every hod-carrier and tinker capable of deciding. So cogent is this consideration that we are driven to the conclusion that, in one body or the other, the decision was determined, not by candid, impartial judgment upon fair evidence, but by a predetermination to convict or acquit without regard to the evidence. Unhappily a perusal of the two records allows no other interpretation. The issue was a simple one. Had the Chief of Ordnance been guilty of fraudulent transactions, and if so, what were they? No mere error of judgment, or difference of opinion, as between impartial men, could, under the circumstances, account for such contradictory decisions. On which side does the defect of justice lie?

A comparison of the constitution and functions of the two bodies may indicate where we may presumptively look for an explanation. The court was composed of three members and a Judge Advocate, viz: Gens. Thomas, Hancock, and Terry, and Judge Advocate Gen. Holt. The members of the court were sworn* to well and truly examine and inquire, according to the evidence, into the matter before them. The examination was by sworn testimony, in the presence of the accused, and was conducted by counsel on both sides. The rules of evidence were the same as in all other military courts, which conform to the practice of United States civil courts, as nearly as their pecular constitution will permit.

The select committee was very differently constituted. It consisted of Messrs. Howard, Cameron, and Drake, of the Senate, and Messrs. Butler, Logan, and Schenck, of the House. Messrs. Butler and Logan were appointed a sub-committee to conduct the examination, the other members taking only a nominal part in it, and being seldom present in the committee room. Mr. Butler was almost the sole examiner. He was governed by no rules of evidence, and no precedents in the matter of practice, except the swearing of witnesses. No counsel was admitted, and no accused person being formally recognized, the really accused party was not present. It will be readily seen that a person so charged with the grave responsibility of furnishing Congress with information, which may be made the basis of intelligent legislation, and vested by that body with plenary power to subpœna witnesses from every corner of the land, without restriction as to whom he shall or shall not summon, or what testimony shall be admitted, and what refused, requires to be a person of surpassing ability, and most especially, to be above all prejudices. He is not merely an examiner, but a judge, whose decision is the only authoritative guide of Congress. We are averse to any invidious comparisons between persons of high distinction, but at the risk of making one, we are compelled to notice the complaints of Gen. Dyer's prosecutors that the finding of the court was "corrupt, arbitrary and illegal," arising out of the prejudices of the members, and a determination on their part to shield a brother officer, regardless of his crimes or the demands of justice. It happens that Gen. Butler has never been at any pains to conceal his sentiments towards the regular army, and doubtless many can recall his remarks at the last session when the army bill was before the House. We would like to propound the question, in view of these utterances, whether Gen. Dyer was not as liable to encounter adverse prejudices before the committee, as his prosecutors were before the court. We are quite content to leave it to the public to judge, whether the truth, in this particular case, was any more likely to suffer from the prejudices of Gens. Thomas, Hancock and Terry, than from those of Mr. Butler. Be that as it may, no one will venture to deny that the strictest impartiality was essential to the position Mr. Butler occupied. And yet, we do not hesitate to say, that he at once assumed the *rôle* of a prosecuting attorney, and conducted his examination in a thoroughly *ex parte* manner, while no opportunity was conceded to develop the other side by other testimony, and by cross-examination. Those who are familiar with legal processes may readily form some idea of what an astute lawyer like Mr. Butler

* Article of War 93.

might be able to accomplish under such circumstances. But this was by no means the worst feature of the case: for after examining witnesses without interference, he was to bring in the verdict. To the most impartial man such a position would involve the gravest responsibility. How did Mr. Butler meet its obligations?

In a technical examination before a legislative committee, where the members are not thoroughly versed, or "expert," in the subject matter of inquiry, it is customary to employ the advice and assistance of expert examiners. Mr. Butler had occasion to avail himself of such assistance, selecting for the purpose Mr. Clifford Arrick of St. Clairsville, Ohio. Most certainly the selection was an astounding one. The important part taken by Mr. Arrick, in the course of the imbroglio, renders necessary such a sketch of him as we are able to give. Some time prior to the war he was an attorney, and subsequently, an examiner in the Patent Office. Here, having become familiar with the progress of invention in rifle projectiles, he at length became interested in an invention known as the Eureka projectile, patented by a Mr. Stafford of New York. By a piece of sharp practice Mr. Arrick obtained a patent for the same projectile in his own name*, and proceeded to urge its merits upon the Ordnance Bureau. Now, shorn of all verbiage, and reduced to its lowest terms, the report of July 17th, 1868, arraigns, tries, convicts and sentences Gen. Dyer, *because he declined to establish the Eureka projectile as the standard service rifle projectile, to the exclusion of all others as worthless*, the ascribed motive being pecuniary interest in a projectile of his own invention. We must digress a little. In the year 1857, Capt. Dyer invented a projectile, which may be considered as the type of a large and varied class. Subsequent developments have shown that he was not the first to apply, what may be termed the essential feature of that class, viz: an expansible cup of soft metal attached to the base of it. Still, he was *an* inventor, having at the time no knowledge of similar devices, and was the first to apply it, in this country, with any degree of success. The opening of the war and the success of rifled cannon abroad gave rise to numberless inventions, and modifications of inventions, of similar purpose, so that the year 1863 witnessed the establishment of several standard varieties, which were used with what were then considered very fair results. Though exhibiting wide differences in mechanical details, they all possessed one common feature, viz: a soft, expansible portion: compressible into the grooves of the gun by the force of discharge. This feature is a radical one in American ordnance, at present, and is sharply distinguished from the system more commonly adopted in Europe, which is exemplified by a projectile having grooves and lands fitting the bore of the gun. Confining ourselves to the American system, its extremes might be well represented by the Parrot and Hotchkiss. The numerous species, which may be said to lie between these extremes, were mostly developed as early as 1863 — all subsequent variations being hardly more than varieties. Some of them underwent modifications, mainly with a view to correct imperfections made apparent by actual service. On the whole, however, no new principle was brought to light. The Dyer projectile meantime had been superseded by the Parrot — its inventor, and, in truth, every other ordnance officer, being so wholly engrossed by administrative duties that no time was found to remedy certain deficiencies disclosed by practice. Up to the time of Gen. Dyer's accession to the command of the Ordnance Department, Mr. John Absterdam had presented two modifications of it, which did not make it in any respect superior and probably not equal to other standard projectiles. Yet it appears to have been the general conviction of the most expert ordnance officers, that a projectile with a soft metal cup at the base *ought* to be the best projectile* and, if properly constructed, would certainly answer the purpose more perfectly than any other. Its defects were felt to be matters of detail and not of principle. These opinions were amply justified by later experiments, when the Dyer projectiles had been subjected to important modifications.

In the latter part of 1863, Mr. Clifford Arrick first exhibited the Eureka projectile

*Singularly enough, Mr. Arrick had been employed as counsel by Stafford in an interference case, in which he succeeded in proving to the satisfaction of the commissioner, that, among several claimants, Stafford was the first inventor. Stafford subsequently assigned his patent to a company of which Mr. Arrick was the agent. Soon after, Mr. Arrick files an application for a patent for this identical invention in his own name, an interference is declared, and, by collusion, Stafford's assignees *fail to appear*! The patent therefore goes to Mr. Arrick by default. (Court of Inquiry Vol II. pp., 223).

* For field service at least.

to the ordnance bureau, and obtained an order for a preliminary trial, at which the action of the smaller calibers was pronounced "fair."* No action was taken by the bureau upon the report, and in the following May, a few more were tried at Washington Arsenal. The experimenting officer reported favorably upon them, with the exception, that the fuses failed to ignite, owing to the entire closure of the windage. After Gen. Dyer acceded to the command of the department, in September, 1864, an order was given for a further trial with 20-pounders having improved means for igniting the fuses. This trial elicited a highly commendatory report,† which warranted their trial on a more extended scale, in competition with standard projectiles;—the caliber selected being the 4.2 inch or 30-pounder. It is held to be a tolerably safe rule, among experts, that a projectile succeeding well in a larger gun will probably succeed well in a smaller, but not *vice-versa*—so that this trial was expected to furnish data only for 30-pounders and smaller projectiles. It was one of considerable importance, for it was expected to result in the restriction of the number of standard varieties. The competing patterns were the Hotchkiss‡, Parrott, Schenkl, Eureka and Absterdam. Early in the trial the Absterdam, made in conformity with his second patent, and closely resembling the older Dyer projectile, failed most signally. But Mr. Absterdam had just obtained§ a third patent, and during the progress of the trial substituted the projectiles made in conformity with it for those which were giving such disastrous results. The trial terminated less decisively than was hoped, and failed to furnish means‖ for a rigid comparison. The Eureka had shown itself to be a good projectile, but not uniformly so. On the other hand, the record of the new Absterdam was decidedly better, while the Hotchkiss, at the very last of the trial, gave, so far as tried, the best results of all;* in brief, the whole question was still in abeyance, except as regarded the Parrott† and Schenkl, which were less satisfactory than either of the others. At all events there was nothing whatever in the trial to warrant the enormous claim put forth by Mr. Arrick, that the Eureka had proved itself to be so decidedly superior to all others, that the Chief of Ordnance was bound to make it the standard service projectile, to the exclusion of all others as worthless.‡ That the court took that view of the case and scouted such a preposterous idea is clear, when it characterized the action of Gen. Dyer as merely an exercise of that discretion which unquestionably belongs to his position. Yet this was precisely Mr. Arrick's claim, as nearly as words can express it. He urged it in a large number of letters§ of portentous

* Made at West Point by Captain D. W. Flagler.

† The Washington trials were made by Lieutenant William Prince, and his reports, forwarded by Major Benton with a formal endorsement, were attributed by the committee to the latter officer.

‡ There were two Hotchkiss projectiles at this trial. The one first employed was the old one, so familiar to all our artillery officers; this is figured in the plate. The other one was quite new, differing from the old one *toto cælo*. It was provided with an expanding cup at the base. It was not presented for trial until too late to obtain thorough results. By an oversight it was omitted from the plate.

§ The drawings in the plate are the second and third Absterdam patents; the one with the brass sabot being the third.

‖ The following is an abstract of the results of the trial as tabulated:

Between February 11th and May 17th, the firings gave the following results: Parrott, 344 shots fired, with 55 bad shots; Hotchkiss (old pattern), 346 shots fired, with 31 bad shots; Absterdam, 232 shots fired, with 19 bad shots; Eureka, 200 shots fired, with 27 bad shots; Hotchkiss (new pattern), 52 shots fired and no bad shots. Ratio of bad shots: Parrott, .16; Hotchkiss (old), .089; Absterdam, .082; Eureka, .135; Hotchkiss (new), none. The Eureka had a very slight advantage over the others in initial velocity and range, in the general average, but was not uniform. The above *comparative* results were dated February 28th, 1865. The results with the new Hotchkiss were not received until June.

TABLE

Of comparative firings of 40 *shots of each variety at* 1,260 *yards, in February,* 1865.

	Total No. of shots.	No. of bad shots.	Percentage of bad shots.	Initial velocity; feet per second.	Direct hits out of 20 shots for range.	Ricochet hits.	Misses.	Vertical deviation, feet.	Horizontal deviation, feet.	Mean deviation, feet.
Parrott ...	40	10	.25	1,201	9	3	8	3.93	9.68	10.4
Hotchkiss .	40	5	.155	1,221	8	3	9	4.60	6.60	8.07
Absterdam	40	3	.075	1,221	6	8	6	2.33	6.23	6.65
Eureka ...	40	10	.25	1,247	10	5	5	3.90	6.70	7.75
Schenkl ..	40	37	.925	1,196						

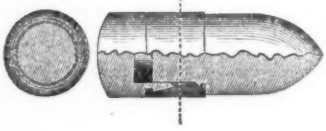
* Only 55 rounds were fired. The results were known only after the war closed.

† To show upon what slight structural differences the efficiency of a projectile may depend, it may be stated, that the only essential difference between the Parrott and the Absterdam is, that in the former the sabot, or base ring, is "flush" with the base of the shot, while in the latter it extends about .8 of an inch beyond it, forming a cup.

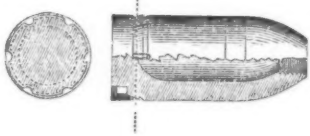
‡ Mr. Arrick made this claim very explicitly and repeatedly. See letters of Arrick to Dyer, dated Jan. 31st, Feb. 6th and 9th, 1866. Court of Inq., Vol. I, pp. 181–183; also id., pp. 196–206.

§ In the month of Oct., 1866, alone, he addressed nine long letters to the bureau on the subject.

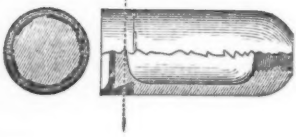
HOTCHKISS.



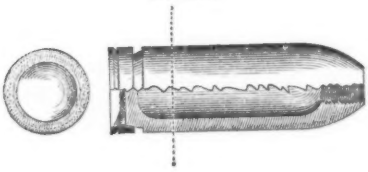
PARROTT.



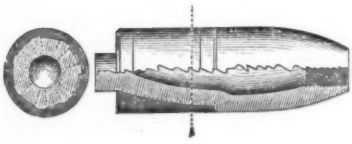
DYER.



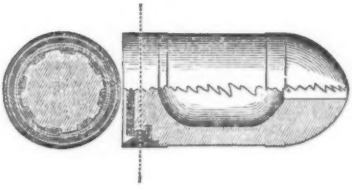
EUREKA.



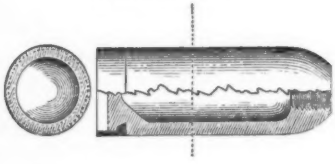
SCHENKL.



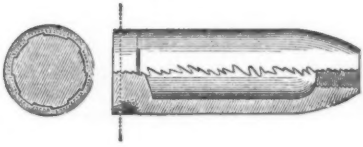
DYER
As modified by Mr. Taylor.



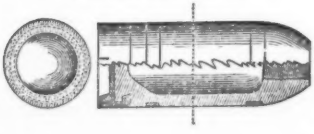
ABSTERDAM,
With brass sabot



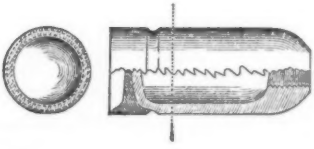
DANA.



ABSTERDAM,
With soft metal sabot.



SELLERS.



length, in which he lost sight of all reason and decorum. He spoke of the demands of the public service upon the Chief of Ordnance, which he was not at liberty to disregard, and insinuated that he was rejecting the only device worth having, by reason of his personal interest in a worthless contrivance which he was endeavoring to thrust upon the service under cover of a false name*, and through the agency of a man of straw. Of course such letters were eminently calculated to carry conviction with them, and to create a warm interest in the Eureka. After a large number of them had accummulated, Gen. Dyer requested Mr. Arrick to state specifically and exactly what he wanted, and received in reply a twenty paged letter,† amplifying the merits of the projectile, and culminating in seven propositions asserting its superiority over every other known device. He then desired the Chief of Ordnance to assent to, or deny them, or in case of doubt to appoint a commission to determine the question upon the records as they then stood. To this Gen. Dyer replied,‡ declining to be catechized; that the *comparative* merits of the Eureka projectile were understood by him, and that he had on hand over 5,000 of them, which would enable him to test their full merits whenever it was expedient to do so. In short, he refused to accept the alternatives of either rejecting altogether a good projectile, or of over-stating and over-valuing its merits.

No person of ordinary intelligence will have any difficulty in correctly appreciating the merits of this controversy. Mr. Arrick claimed to have an invention which ought to supersede every other for similar objects. But was there ever a patentee who was not ready and eager to claim the same thing? For five years or more the Ordnance Office was daily thronged with sanguine inventors, and owners of inventions, making the same claim, each strenuously asserting that he had anticipated for many years to come all possible improvement in a particular direction, and thinking that the Chief of Ordnance, and all his subordinates, were the embodiments of stupidity, because they thought differently. Each inventor seemed to entertain the idea that the Government was bound to accept off hand, or, at least, to try his own particular contrivance. Let some statistician calculate the expense of satisfying, either by acceptance or trial, the expectations of these gentlemen, and he will be edified. Are men of business in the habit of purchasing new inventions without knowing their merits? Are they in the habit of testing them for the sole emolument of the inventors? In a word, is not the usual and proper course, in such matters, to purchase them if you think they will pay, and to let them alone if you don't? Now, what earthly reason is there why the Government, through its officials, should throw away this prudent and universal practice? These officers are required to judge of the exigencies of their respective departments, precisely as the proprietors of private establishments judge of theirs, and to manage them in the interest of the Government, and not of inventors and contractors. Mr. Arrick demanded, in no very gentle terms, that his projectile be accepted, against the judgment of the department, and upon no decisive record, though he afterwards proposed to subject it to the form of a trial§ which would cost $20,000. As the department had on hand an enormous supply of projectiles, which, in its opinion, were as good as, not to say better than, the Eureka was likely to prove, it was deemed inexpedient to spend a large amount of public money in settling a question of no practical importance at that juncture. Even admitting, for the sake of argument, that the Eureka may prove to be somewhat superior to any other ever urged upon the bureau, is the Government, at the close of a gigantic war, and weighed down with debt, to incur further expense in demonstrating the value of an article it does not want?

After four years of solicitation; after he had become intolerable to the bureau and everybody connected with it, Mr. Arrick came to the safe conclusion that he had spent much time and money to no purpose. We believe his friends will not assert that, in his wonderful persistence, he was so disinterested as to work from purely patriotic

* Letters of Arrick to Dyer, Feb. 9th, 1866, Court of Inq. I, 182, and id., Oct. 16th, p. 198. Mr. Arrick claimed that the Absterdam was but another name for the Dyer projectile, and that Gen. Dyer was receiving royalty on the purchases, and using Absterdam to conceal the transaction. This is the gist of some of the accusations in the report of the committee.

† Letter of Arrick, Oct. 25th, 1866, Court of Inq., Vol. I, p. 201.

‡ Letter of Gen. Dyer to Arrick, Oct. 27th, 1866. Id., p. 203.

§ Arrick to Dyer, July 9th, 1867. Id., p. 222.

motives, nor are we aware that he claims any motive but the pursuit of emolument; and when we find him thoroughly committed to the serious undertaking of the overthrow of the Ordnance Department, we see no escape from the conclusion that his incentives were money, and, perhaps, revenge. We are by no means left to conjecture alone on this point. He expressed himself ready to relent if his claims were conceded by the bureau*, but in the other event he was resolved to spare no effort to demolish it. It seems that he did not lack powerful co-operation. We are not aware by what means his determination was made known to the Select Committee, nor is it material. His own account of the affair is, that he knew the committee wanted him, and were about to send for him, and he anticipated their summons†. And so Mr. Arrick became the expert examiner and adviser of the committee in the investigation of Gen. Dyer's action in the purchase of rifle projectiles.

Were it necessary we would detail some of the operations by which testimony before the committee was perverted; how Mr. Absterdam was made to testify that he had no patents, when he had them in his pocket; how indignant the old gentleman got when he told the court that his evidence, as it appeared in the record of the committee, was a mutilation, a forgery, and he repudiated it‡; how the Absterdam projectile, of the third patent, which had been purchased so extensively, was shown to be "absolutely worthless" by quoting the record of projectiles made under the second patent§—a different affair altogether; how a poor woman was made to testify‖ that Gen. Dyer had claimed a royalty on these projectiles in the Ordnance office, and in the presence of several individuals; a statement which Mr. Field, by a few minutes cross-examination, showed to be an ambiguous perversion of a remark which did that officer no little honor. But we pass them by, for they are all rendered ineffectual by the finding of the court.

A fitting termination to this marvelous investigation was the preparation of the report. After giving over the body of the Chief of Ordnance to his adversaries, to wreak such vengeance upon it as they saw fit, and to toss and gore it in the committee-room, it might be thought proper that the drawing and quartering of the remains should have been done by the representatives of the law. But the committee thought otherwise.

Mr. Arrick states, in his testimony before the court, that, by a general understanding with the committee, he wrote the report, presented it to Mr. Butler, who read it over, reduced it by striking out certain passages, and re-committed it to Arrick, who made the connections and again submitted it to Mr. Butler, by whom it was accepted and presented to the full committee, who in turn delivered it to Congress as the report, in part, of the Select Committee on Ordnance. *The whole text was written by Mr. Arrick, verbatim, as it now appears, with the exception of the last three lines.** As nearly as we can figure it, this report cost the country in the neighborhood of $200,000, and the net result of the expenditure is, that Congress and the country have been enlightened as to Mr. Arrick's opinion of the Chief of Ordnance! Why! Mr. Arrick was boiling over to give it to them for nothing but the asking!

The next subject, covered by the report of Feb. 15th, 1869, was that of heavy guns. Mr. Butler being occupied with the impeachment case, took no active part in this—his place being, in a measure, supplied by Mr. Howard. This subject being far more difficult in point of scientific principles involved, the same necessity existed for a resort to expert assistance. That an eminently qualified person should be selected was a matter of the first importance. To convey to Congress information which would enable that body to form a correct, comprehensive, and concise opinion of the state of modern ordnance in general, and of American ordnance in particular, is a task from which the most accomplished expert in the land might well shrink.

In England, during the last fifteen years, not less than £25,000,000 sterling have been expended by Government upon experimental artillery. Enormous sums, of which we have no record before us, have been expended in a similar way by the continental nations of Europe. The most accomplished engineers, army and navy officers, iron masters and mechanics, have added their severest

* Arrick to Charles Knapp, Feb. 22d and Mar. 7th, 1868. Id., Vol. II, p. 341.

† Arrick's testimony, Id., p.

‡ Compare Absterdam's testimony before the committee with that before the court, Vol. I, pp. 28–29.

§ Cross-examination of Clifford Arrick, Court of Inq., Vol. II, pp. 228–229.

‖ Testimony of Mrs. E. Dixon, Id., pp. 362–371.

* This is Mr. Arrick's own version of the affair, Court of Inq., Vol. II, p.

labors, and most strenuous efforts of intellect and capital, to aid in the solution of the ordnance problem. In England, France and Germany, where new processes and new machinery for the manipulation of iron and steel have succeeded each other with marvelous rapidity, and upon a constantly increasing scale of power, the utmost that has been looked forward to, is some process which will render practicable and reliable the construction of the enormous guns demanded by modern warfare. In America, owing to the greater scarcity and cost of capital, and the backward condition of machinery for manipulating large masses of metal, no such immense establishments as those of Sheffield, Birmingham and Essen, are in existence. The attention of ordnance officers and civilians has therefore been confined to such materials as the workshops of the country are capable of manipulating, and that material, so far as the largest guns are concerned, is cast-iron. In this limited field have been employed the talents and energy of our most practical and learned constructors. The question of ordnance has long involved the labor of the highest mechanical genius, the most ponderous machinery, the largest accumulations of private capital, and the most lavish expenditure of public funds of any scientific question before the civilized world. Whom, then, did the honorable chairman of the Select Committee on Ordnance select, as his representative, to elucidate and expound this lofty subject to the national legislature? We have no hesitation in asserting that, out of the thirty-five millions of people in these States, Mr. Howard selected the man possessing the most obnoxious disqualifications, and the greatest number of them.

We pause here to apologize to the readers of the ECLECTIC. We are adequately impressed with a sense of the dignity and impersonality which should characterize all professional discussions. We also asseverate a profound respect for the wisdom, patriotism, and official dignity of our national legislature, which we desire to extend to all its constituent parts and members. But we find ourselves embarked in a serious discussion, which brings us face to face with a most anomalous state of affairs. On the one hand, we find a man making the loftiest kind of pretensions to professional science, and yet is at the farthest remove from it. These pretensions are not made quietly, modestly, and deferentially, in the ordinary range of private or literary discussion, but coarsely, blatantly, and abusively, before a high inquest of national importance. On the other hand, we find a congressional committee accepting implicitly these false pretensions, and using their high powers to push their consequences to the uttermost. We have a general interest in this matter, as a lover of truth and a citizen of the republic, and we have a special interest in it as a member of that small but select body, whose professional reputation is immediately assailed. What is our duty in the premises? Is there any alternative but to tell the whole truth, regardless alike of personalities, or of the character of any committee whom our honorable Congress may see fit to designate?

The person we refer to is Mr. Norman Wiard. He, too, was a disappointed aspirant for wealth through dealings with the Ordnance Department. Like Mr. Arrick, he had an invention to offer, the adoption of which he had urged through long and weary years, with an energy and importunity such as is known only to that desperate class who throng the departments and infest the portals of the capitol. Many of them are men of capacity, and certainly some of them mean to be honest. Some, too, have personal qualities, which, if exercised in a moderate but honest capacity, and controlled by moderate and rational ambition, would make them invaluable members of the community. But they are men of desperate need, and, at the same time, bitten by an inordinate desire to accumulate wealth out of public patronage. Their ravening hunger obliterates all perception of public interest and morality. Now, if eight years of untiring solicitation for the Government acceptance of chimerical schemes, the receipt of $136,809 in Treasury drafts and certificates, for which the Government cannot, and never could, show $25,000 worth* of effects; the repeated memoralizing of Congress† against zealous and upright officers, and in favor of a corrupt scheme of private emolument at the public expense—if hob-a-nobbing with

* All of the ordnance material furnished by Mr. Wiard to the army and navy, excepting such as was made in conformity with regulation patterns, was found to be unserviceable in the field. The army commanders who had requested a supply of his semi-steel guns, were the first to request their withdrawal.

† There are several memorials of Mr. Wiard to Congress, the most infamous being that which was referred to the Committee on the Conduct of the War, in 1865.

those Congressmen who are not particular about the company they keep, and persuading them to recommend that Congress appropriate $125,000 for a claim* which is fraudulent in its very essence—if instigating and procuring the appointment of a congressional committee† to recommend the dismissal of a select corps of zealous public servants, for no other earthly reason than because they refused to lend themselves to these iniquitous schemes; if these things entitle a man to a high position in the category of the "third house," as we have described it, then Mr. Norman Wiard belongs there. We wish it distinctly understood that we make no charges which we cannot prove under the seal of official record, and we shall in due time give the proper references.

We shall first proceed to characterize the peculiar invention he has sought to establish. Mr. Wiard was occupied, in the year 1862, in the fabrication of some semi-steel 50-pounders for the Navy Department. When subjected to a very moderate test, these guns burst with surprising facility. In speculating upon the reason why a metal, having such high tensile strength, should exhibit an endurance inferior to cast-iron, he came to the conclusion (by what logical process he does not inform us) that some agency was concerned in the destructive effects of firing, other than the mere expansive force of powder. It at length appeared to him that the intense heat of the ignited powder, together with that produced by the friction of the shot against the surface of the bore, would occasion a difference of temperature, as between the interior and exterior, tending to compress the former and extend the latter. Guns fired rapidly, would, in this way, be subjected to a constantly increasing tension, which, added to the force of the discharge, would ultimately produce rupture. Satisfied that he had solved the problem, and that his solution covered every case of rupture, he applied himself to the devising of a gun which would compensate this difficulty. In 1864, after much solicitation, he procured from the Navy Department a contract for the construction of two 15-in. guns upon his plan, designed to obviate the supposed effects of heat. The first gun was condemned in the pit; the second was finished and broke into many pieces at the first discharge. The department did not deem it advisable to expend any more money upon an experiment of this character, and although Mr. Wiard's importunities have been very great, they have been invariably declined.

A discussion of the hypothesis he has advanced, we must decline entering into, further than to state a few facts. That a gun is heated by firing, that the heat so produced is greater in the interior of the gun than at the exterior, and that the difference of temperature may, in most cases, produce to a small extent the tensions Mr. Wiard assumes, are doubtless true. But the question is one of degree. Mr. Wiard assumes that these tensions are something enormous—every gun founder and constructor of experience knows them to be so small as to be practically immaterial. But whether they be great or little, his proposed plan for obviating them will appeal only to "the risibles" of the true mechanic, and if it has never been duly characterized by competent authority, it is because such authority has deemed it too bizarre and whimsical to dignify it with notice. There are two ways of substantiating a physical hypothesis—one analytically, by mathematical demonstration; the other empirically, by experiment, and a complete demonstration should properly involve both. Mr. Wiard has given no analysis of the effect of heat upon the metal of a gun, and his hypothesis, therefore, rests upon no theoretical basis. We cannot recognize the statements he has made concerning the effects of heat, or sudden cooling, upon various masses of metal as having any bearing whatever upon the thing to be proved. When he submits an analysis showing, within a reasonable approximation, the amount of heat communicated to the gun, the rate at which it is conducted through the mass, the degrees of tension produced, and the relations of these forces to the ultimate strength and elasticity of the iron, intelligent mechanics will be happy to give it such careful and respectful consideration as it merits. At present they have no tangible theory to work upon, but only a few incoherent assertions on his own authority, which is opposed to that of all constructors known to the public. As for facts, they are all against the hypothesis. No gun ever burst under circumstances which could prop-

* Fortieth Congress, Third Session, House Report No. 6.

† There is no room for doubt at whose instigation the committee was appointed. The numerous letters of Arrick, Wiard, and Horatio Ames (see Vol. II, Court of Inq.), contain abundant evidence that they procured it, and were able to control it.

erly warrant the assumption that it was due to any cause, other than the expansive force of gunpowder. But numerous experiments* have been made with a view to test this question. Guns burst indifferently, whether fired rapidly or slowly, or, as in the case of some of Mr. Wiard's, at the first discharge, in which the assertion of such a cause is a contradiction of terms.

Mr. Arrick is a true expert, and the contrivance he urged upon the bureau had great merits; but Mr. Wiard is a charlatan, and his gun a mere monstrosity. In his evidence before the committee he undertakes to expound the nature of the mechanical forces involved in the action of gunpowder. Whoever will take the pains to read that exposition will, if he be versed in the doctrines of mechanical science, at once recognize the fact that the whole testimony is an imposture—a pretense—an aping of knowledge, which he does not possess, and never can possess, until he has at least gone through a course of study and instruction, such as is required of every school-boy who becomes a candidate for a bachelor's or professional degree. It is a bold attempt to persuade the committee that the laws of force, as taught by every mathematician since the days of Galileo, are foolish misconceptions, and that the only true wisdom the world has ever seen, has found its incarnation in Mr. Norman Wiard. The notions of this man are no ordinary errors. They are such as can exist only in the absence of a capacity to understand the fundamental principles of mechanics, as taught in every school book, and elaborated in every treatise, from the theory of falling bodies to the *Mechanique Céleste* of Laplace. Either the whole world beside is utterly wrong, or else Mr. Wiard is—not only in special deductions, but in the simplest principles, which every unbreeched school-boy is bound to know. Really, matters have come to a strange pass, when the Ordnance Department is to be compelled to defend, not merely its system of ordnance, but the first principles of Weissbach, Bartlett, and Moseley, against the assaults of an imposter. We should like to see Mr. Wiard, or anybody else, take his assumptions about the "projectile force" of powder,* and apply them to the fundamental equation $Q = \int P\,ds$, and to see where he will come out.

Whoever likes to contrast the insolence of ignorance with the modesty of true knowledge may turn to the testimony of Gen. Rodman. Here is an officer whose reputation as a man of high scientific attainment is world wide, and whose practical experience in gun founding is as extensive as that of any living man. His statement of the merits of the system which bears his name is qualified by a full acknowledgment of the limits of its advantages, and an humble sense of the difficulties which beset the whole subject, arising partly from a want of experimental knowledge, and partly from the unsuitable nature of the materials we have to deal with. Mr. Wiard, a man innocent of learning, who never made a reliable gun in his life, lays claim to complete knowledge, where all other men are silent, solves by a dictum every moot question, and charges other men with ignorance, stupidity and dishonesty.

But we have more serious charges to bring against Mr. Wiard than mere ignorance. In

* After the action of Fort Fisher, several 100-pdr. Parrotts were fired over 1,000 rounds each, one of the objects of the trial being to determine whether rapid firing exerted any appreciable effect. (Of course it is possible to fire more rapidly experimentally than in action, where time is consumed in sighting.) Nothing was developed by the experiment. It has become usual to conduct a part of the extreme proof of guns with the same view. No appreciable effect has ever been observed to result from rapid, as distinguished from slow firing. Out of the enormous quantity of exper mental firings which have been made, it is a sheer impossibility that any such cause could escape detection if it had any real existence.

* Mr. Wiard seems to entertain the idea that the velocity of the projectile is the result of *two* forces, viz: the static pressure of the ignited powder, and the *vis viva* with which the powder is projected against the projectile. After elaborating this view with considerable minuteness, he then proceeds as follows:

"Q. What is the difference between the projectile force and the pressure of the powder, and has one a fixed and continuous relation to the other?

"A. The projectile force of the powder is the force equal to that which would be developed or exhibited in stopping the projectile. The pressure is that force which gives it motion in the gun, and it can be seen that if such a force as that acting upon the projectile should act against the surface of the bore in the gun, no material could be found from which guns could be made, which would not either enlarge the bore, or burst as a gun, unless it were from material which, if formed into a plate, and fixed upon the side of a ship as armor, would resist the impact of a shot from a gun without any indentation whatever. When a wrought iron shot is fired from a gun at a plate, which it does not penetrate to any considerable depth, the shot is flattened by the impact. If the pressure of the powder were not less than the projectile force, the shot would be invariably flattened to the same extent in the gun, which, however, is not the case."

We leave the educated mechanic to groan in spirit over this.

his testimony* he refers to a report of the Chief of Ordnance, which speaks of certain "ignorant, or designing persons" who have "hindered the furnishing by the Department of 1,915 large guns." Mr. Wiard says, "I hope you will credit me with having prevented the perpetration of a gigantic swindle thereby." We are much obliged to him for the word. We shall probably agree as to its meaning and differ only as to who is the swindler.

In October, 1861, he received from the Navy Department an order to finish a number of 7½ in. guns†, the blocks being furnished him. Having no means of his own he sub-let the work to one, William A. Miller, of New York. When nearly completed, an inspection was held, and it was reported that $5,270.00 had been earned, which amount was paid to Norman Wiard. Mr. Miller never saw a dollar of this money and held the guns as a lien. Their delivery was demanded of Mr. Wiard by the Navy Department, but he failed to respond and ultimately the guns were forcibly removed by the Commandant of the Brooklyn Navy Yard.

In August, 1861, Mr. Wiard received an informal contract to furnish the Navy Department with a number of semi-steel 50-pounders.‡ They were to be deliverd in lots of five, and upon the notification of the acceptance of each lot after inspection, an order for a new lot was to issue. The first six guns submitted for inspection failed§ most signally. Three of them burst by firing less than eleven rounds with five pounds of powder, and a fourth—the trial gun—had been disabled after some 350 charges. One of these guns, after bursting, was found to contain a false bottom, which had been inserted to hide an error of dimensions. In the investigation which followed, Mr. Wiard asserted his ignorance of the fraud and charged it upon various manufacturers and artizans who had immediate charge of the work. One of these persons acknowledged the sole responsibility and in his defense made some very significant disclosures. His statements were sustained by the affidavits of four men*, who were in no wise implicated in the fraud, and whose testimony is unimpeachable. It seems that the practice of doctoring sick guns was a most extensive one at the establishment where Mr. Wiard's 50-pounders were made, and that he himself inaugurated the system. Flaws were hammered up, seams brazed and holes plugged with screws.† Guns which had been rejected were artfully tinkered‡ and restored to their vacant places—all by Mr. Wiard's own orders in almost every case specifically, and against the repeated protests of his manufacturers.

Of these 50-pounders the Department accepted only one—the first and trial gun, which was paid for. Mr. Wiard made ten, of which four were never brought to trial. Of the other six, two were fired ten times without injury and landed by Mr. Wiard at the Navy Yard. They were never received by the Government, and yet Mr. Wiard presented a bill for them,§ amounting to $9,671.30. As the Department declined to pay for them, he proposed that the subject be submitted to a commission, promising to abide fully by its decision. The commission was appointed conformably to his request, gave the matter a full hearing, and reported adversely to his claim. We shall soon see how he kept his promise.

In April, 1863, Mr. Wiard entered into a formal contract‖ with the Navy Department to cast a 15-in. trial gun upon his peculiar plan, designed to obviate the effects of heat. When ready for trial he was to receive one-half the full price, which was to be 25 cents per pound, the balance to be paid when the trial was completed. In case of failure he was to be allowed to make a second gun under the same conditions, which, if successful, was to be considered as the trial gun. As we have already stated, the first gun was

* Testimony of Norman Wiard before committee. Report of February 15, 1369.

† See letter of Sec. of Navy to Senate 41st Congress, 1st Session, Senate Ex. Doc. No. 11, March 31st, 1869. This document is a compilation of official correspondence between Norman Wiard and officers of the Navy Department submitted without comment. The statement we give we vouch for as being a correct epitome of the statements therein contained.

‡ The whole history of these 50-pounders will be found in the document just referred to.

§ One was fired 350 times when it showed an excessive enlargement of the vent; one burst at the ninth fire; one at the tenth; one stripped a land at the first fire and exhibited at the tenth fire a crack about four feet long.

* See affidavits of William L. Miller, George P. Gernster, J. T. Plass, and Isaac F. Tice. Id. pp. 52–58.

† Id.

‡ Every iron maker knows well enough that of all forms of iron the most treacherous and worthless is semi-steel as it is called. It is in effect a wretched half kneaded and half cooked variety of wrought iron utterly unsuitable for any purpose known to the arts.

§ Id.

‖ Id. The contract in full is published in the document referred to.

an imperfect casting; the second burst at the first fire, and terminated the contract. Mr. Wiard was paid $5,160.00 for the first gun,* and $4,295.00 for the second. In acknowledging the receipt he signed an explicit statement† that the acceptance was a final settlement of all claims against the Navy Department.

On the 13th of January, 1869, Mr. Schenck, in behalf of the select committee, reported to the House‡ a bill appropriating to Mr. Wiard the sum of $42,180.00 for nine semi-steel 50-pounders, and $83,668.49 for various expenditures attending the preparations for, and the construction of, two 15-in. guns, making a total of $125,848.49. Through the personal representations of Mr. Schenck this bill was passed by the House, and went to the Senate, where Mr. Howard, the chairman of the select committee, urged its passage. Fortunately, Mr. Grimes of the Naval committee happened to be aware of the true nature of the scheme and at his request the bill was defeated.

We have been permitted to see the original of the following letter, to the genuineness of which we can certify. We withhold the name of the firm to which it is addressed out of deference to their desire to avoid a publicity nowise agreeable to them. At the same time they are ready to make any acknowledgments which public interest may require.

MAY'S BUILDING, ROOM 3, COR. 7TH AND E,
WASHINGTON, 21st June, 1869.

Gentlemen: It affords me gratification to be able to forward to you by mail a copy of the last report of the Joint Committee on Ordnance on the subject of heavy ordnance.

I do not know how far you have made yourselves acquainted personally with the theories I have advanced for the past eight years, in relation to the "ordnance problem." I therefore, also forward to you a copy of a communication I made to the committee on the conduct of the war, early in 1865, believing that you cannot fail to appreciate the renewed consequence, which attaches to the subject, by the determination of the fact, that 1,915 large guns are required for the fortifications, according to the report of the Board of Ordnance Artillery and Engineer officers, approved 20th of February, 1867, concluded, as shown on page 171 of the report of the Ordnance Committee; and in view of the facts, that the Rodman system is now condemned by the appropriating branch of the Government, the Parrott system being no longer in competition, and the Dahlgren gun obsolete, on account of the changes in the means of defense adopted in all countries, I flatter myself that my views on this subject are in the ascendant.

While the Rodman patents were operative (they expired last year), the money interest, with which they were sustained, could overwhelm me. Now feeling confident that I possess the only practical manner of making large guns, and that it is secured to me unassailably by patents, issued or to be issued, I hold that I have achieved a monopoly of the gun business of the future, according to law, and if any of those parties, who have heretofore opposed me in the interests of the Rodman patents—now that those patents have expired—should continue their attentions in a revengeful spirit, I have only to invoke the majesty of the law and they will be removed. As evidence of this, I forward a third publication, to which I ask your attention.

And now the real object of this letter: I am about to enter upon the gun business, either by building a foundry in Washington, or by making an arrangement with some of the already established foundries, for the production of guns upon my new system, and I desire to know if this fact interests you in any degree. I have no idea that I could impress you favorably with my plans, otherwise than at a personal interview, which I should be glad to promote, if I should learn that you were desirous of participating in it—not otherwise.

If you have any doubt of my skill, persistence, or integrity, or security—and I know there have been some reasons for doubt spread abroad—I desire to refer to Mr. Sam. Sinclair, of New York City, a gentleman who has known me well for many years. Mr. Sinclair is publisher* of the Tribune.

Hoping you will respond to this,

I am, Gentlemen,
Yours &c.
NORMAN WIARD.

It is certainly a most unpleasant task to us, dealing in such personalities; but we have no alternative. A great congressional committee has paraded Guy Fawkes before Congress and the country, and we are bound to hurl missiles at the effigy—or to borrow a stronger phrase from Macaulay, "the attempt to enshrine this carrion has compelled us to gibbet it."

The reader of the ECLECTIC will now be able to form some conception of the mockery of that investigation. It was an additional refinement of injustice, over and above that, in which Mr. Arrick figured so extensively. In that one Mr. Butler kept up the outward form of an investigating committee; but in this Mr. Wiard filled the chair, prepared the questions, catechized Admiral Dahlgren, Gen. Rodman, Col. Laidley and finally himself. The situation of the two former officers forcibly recalls the description in the Pilgrim's Progress of the trial of poor Faith-

* Id.

† Reading as follows: "I hereby accept the above as a final settlement of all claims against the Navy Department."

‡ Fortieth Congress, 3d Session House Report, No. 6.

* Which will account for the periodic onslaughts of that journal upon the Ordnance Department.

ful before Lord Hategood and the jury of personified vices at Vanity Fair.

"JUDGE.—Thou runagate, heretic, and traitor hast thou heard what these honest gentlemen have witnessed against thee?

"FAITHFUL.—May I speak a few words in my own defense?

"JUDGE. — Sirrah sirrah! thou deservest to live no longer but to be slain immediately upon the place; yet that all men may see our gentleness to thee, let us hear what thou, vile runagate, hast to say."

We are not prepared to assert positively that Mr. Wiard drafted the report, because we have no direct proof; but judging from internal evidence we entertain little doubt of it. That, however, is scarcely material. The report is all he could have wished it to be. It condemns every system of ordnance except his—denounces in most opprobrious terms the Ordnance Department and its system of artillary, and recommends its abolition, and the substitution of a mixed board of officers and civilians. We do not see what he could have desired to add, unless it be the appropriation of a large sum of money for his own benefit, which the committee sought to effect in a more efficacious way by a separate report.

We have entered more deeply into the personal details of this business than was agreeable to us, because we have felt that in exposing the characters of these men we are enlightening the mechanics and engineers of the country as to the animus of the committee. In their individual capacity we are desirous to avoid all contact with Messrs. Arrick and Wiard: they are formidable only through their connexion with the committee. Since the committee placed its high authority unreservedly into the hands of these men, with no restriction as to its use, and making it merely a cover for whatever they chose to say, we are bound to show the characters of the men who were the recipients of this confidence. The real committee was Messrs. Arrick and Wiard, and the lawful committee stepped in only to give the investigations of these two men the weight and sanctity of its official character.

We feel that it is not for us to assault formally the characters of Senators and Representatives further than to state facts. The inferences we shall leave to the readers. Here are two reports—the first, written by Mr. Arrick, vituperating the Chief of Ordnance for no alleged and no conceivable reason except that he declined to make the Eureka the standard rifle projectile "to the exclusion of every other known device as worse than worthless;"—the other, written (in all human probability) by Mr. Wiard, vilifying the whole Ordnance Department, because it equally rejects his grotesque cannon. And yet, after the form of an investigation, the committee adopts them in all their grossness and in all their *ex parte* character—recognizes their serious consequences, as involving an entire change of the management of the ordnance service, and a substitution of the material of these adventurers for that already in vogue. If it be said that the committee may have been deceived, and led to espouse the cause of these men through artful misrepresentations, then the reader may ask himself, what right had they to be deceived, when they were so explicitly charged by Congress to ascertain facts and report them? What right had they to base an opinion of a considerable and honorable body of officers, upon the sole representations of their bitterest enemies?

We cannot close without adverting to the recommendation that the Ordnance Corps be abolished. That is a matter for Congress to decide, and any decision which may be made by that body, after a full and impartial investigation, and when it is in a position to comprehend and appreciate the subject in all its bearings, will be most cheerfully acquiesced in by the officers affected by it. Probably no corps of public officials could so well bear to be thrown upon their own resources, or is better qualified to meet the exigencies of an entire and forcible change of profession. But an honorable discharge from the service is one thing, and being kicked out for refusing to facilitate the various schemes of plunder set on foot by the Arricks and Wiards of the Washington lobby is quite another. The charges of incompetency, of the "lack of the incentive to exertion and improvement, which stimulates men not in the Government employ," the "attchment to routine," "jealousy of innovation and new ideas," "discouraging the inventive talent of the country," and the "improper and oppressive treatment of persons, who have sought to call their attention to what were supposed to be vital principles of the art" etc., etc. will pass for what they are worth. They mean simply that the Department could not appreciate the "new ideas," the "inventive talent," the "vital principles of the art," involved in Mr. Wiard's "Munchausen Artillery."

That a strong pressure will be brought to bear upon Congress, the coming winter, to abolish the Ordnance Department, or merge it into the artillery, we readily foresee. We are not disposed to make any plea for its continuance, except on the ground of public expediency. It is certain that there must be a class of officials, either military or civil, whose special functions must be the administration of ordnance duties and the provision of ordnance material. It is for Congress to judge whether these functions will be best fulfilled by civilians, or by the military; by officers specially educated for it and of protracted experience, or by officers without experience. The term ordnance is suggestive of guns; but in reality involves a whole world of executive details. It comprises manufactures, a knowledge of business, of fabrics, and of construction, far more extended than any mere trade or class of trades. Its officers are *entrepreneurs* between civilian supply and military consumption, and to be efficient and economical—to insure to the Government an equality in bargains and protection against fraud, to regulate supply by the demands of the service and to systematize the means and methods of supply, must be men who are thoroughly acquainted with the mechanic arts, the trades, the details of ordinary business, and the routine of military service. These duties must be discharged by a body of specially qualified men or the abolition of the present Ordnance Department will merely render necessary the construction of another. It would be a change of persons and not of system.

We are tempted to make one remark which we hope some Congressman will see and make a note of. If the Ordnance Department is worth anything, it ought to have the confidence of both Congress and the people. But if its recommendations are to be disregarded, its aims and purposes defeated, and its chief and his subordinates arraigned and thrown upon their defense every time an over sanguine inventor or unprincipled adventurer chooses to impeach them, then it is high time to abolish it. Like every other subordinate branch it derives its efficiency and capacity for usefulness from the confidence of the Government.

A comparison between the merits of the American Ordnance and foreign may be made briefly. As yet American Ordnance contains no *established* system but the Rodman Army, and the Dahlgren Navy, guns. The large calibers are all smooth bores. The few rifles, which have been subjected to experiment, have not given such results as to warrant their adoption;—partly because the trials, which have been made, have not accurately tested the proposed system, and partly because the trials have been exceedingly meagre*: nothing is predicted for them, but much is hoped. As for the large smooth bores, they have hitherto sustained every test, and no one of them, in the army at least, has ever burst, except after a good and sufficient measure of endurance. For the Navy we are unable to speak. During the war the Parrott rifles were extensively used. A considerable number of these burst, although the general performance of them —all things considered—was wonderfully good. These guns may be considered either good or bad, according to the standard by which they are judged. If a perfect gun be demanded, a gun which will never burst, no matter what the caliber, or the charge of powder used, then the Parrot gun was a failure. But if there be demanded as good a gun as could be built at a practicable cost, and with reasonable celerity, and which would endure, in nineteen cases out of twenty, a liberal amount of service, the Parrott gun was eminently a success. During the late war there was no large rifle in existence to be compared with it. If the carping critic chooses to point to its failures, instead of its good service, the reply is easy. It was by an immense interval the best gun of its class at that time, and it remains to be seen how much improvement has been made, since 1865, in the construction of heavy rifled artillery. That better guns have been made in England and Prussia is admitted; but whether they can be furnished in quantity, of a guaranteed endurance, and at a practicable cost is not yet fully decided. The Parrott† rifle has been adopted only provisionally until a better system can be established.

Turning to European Ordnance, we find everything in a transition state. The colossal works of Krupp, at Essen, have produced enormous rifles, which have been fired with heavy charges about 400 times, and more recently the Fraser gun has given re-

* Of the heavy Rodman rifles only three have been put to proof. One 12-in. rifle was fired 470 times before bursting; one 8-in. rifle fired 1,080 times and one 8-in. rifle 80 times.

† The country owes much to Mr. Parrott. His services have proved far more valuable than those for which Sir W. Armstrong was knighted.

sults, which are certainly promising, having sustained over a thousand fires with charges of great strength. But no European Government entertains, as yet, the least notion of adopting any one of the many systems undergoing tests, until these tests shall have accumulated so as to place the endurance of the guns beyond the possibility of a doubt. Any other course would involve a most unwarrantable risk. The enormous cost of such guns would render their definitive adoption a matter of as much solicitude as a cabinet crisis or a *coup d'état*. In brief it is safe to say that there is no system of Ordnance in Europe, whose merits are known, or which has been accepted as a system. We have in this country the Rodman system of smooth bores, which has been tested through all calibers, except the 20 in., with results which have given, as yet, no instance of failure. If we are unable to assert that it is superior to any other, we can at least assert a tolerably accurate knowledge of what it is capable, which is more than can be said of any European system. The Ordnance question in this country is not between the Rodman system and a better one, but between the Rodman and three or four whose merits are not determined. Meantime, as has already been stated, American constructors are confined to the possibilities of cast-iron, and in that restricted field American Ordnance is far beyond the competition of any foreign nation. Our irons are unequalled, our workmanship unexcelled, our accuracy of detail in the minutiæ of the process and the absolute certainty of our results, are as nearly perfect as it is possible to be. With the examples of England and Prussia before us, the Ordnance Department is reluctant to advise—especially at this juncture—the embarking upon that boundless ocean of expense, which seems necessary before it will be possible to arrive at an experimental determination of the superiority of wrought iron and steel cannon; and until those nations exhibit results corresponding in value to the enormous outpouring of money upon experimental guns which the last ten years has witnessed, prudence at least should admonish us to bide our time. Whatever the Krupp and Fraser guns may be, it is certain that they are not yet afloat, nor frowning from casemates: it is certain too that they will not menace us, until their builders know what they are good for. When that eventful time arrives, when other nations are prepared to adopt them and arm their batteries, afloat and ashore, with them, then, and not until then, will it be time to ask whether the Rodman system should be superseded. D.

STEAM POWER METERS.

From "Engineering."

There are probably but few of our readers who, being employers of steam power, have not at some time or another desired to ascertain with exactness the total amount of work done by an engine in a given time when running with a variable load, and who have not been struck by the difficulty which exists in obtaining such information by any ordinary means. So long as the work performed by an engine is tolerably constant, indicator diagrams taken at frequent intervals, and carefully worked out, will give the desired information with sufficient accuracy for most practical purposes; but, except in the case of pumping or blowing engines, the work done by an engine is seldom really constant for more than a very few minutes together, and the consequence is that ordinary indicator diagrams, unless taken in rapid succession and in considerable numbers, do not afford data from which the total power developed in a given time can be calculated with any degree of accuracy. Moreover, the working out of a large number of indicator diagrams is a tedious task, and requires a considerable expenditure of time even if the assistance of a planimeter is available, and it thus but rarely happens that an attempt is made to ascertain with exactness the power developed by an engine doing variable work.

To facilitate the taking of a number of consecutive indicator diagrams, Mr.—now Sir Daniel—Gooch, many years ago employed, on the Great Western Railway, his continuous indicator, in which the diagrams were traced by the pencil on a continuously moving strip of paper: a plan which obviated some of the difficulties of the case, but which in no way diminished the labor requisite to obtain from the diagrams a knowledge of the power which the engine had been exerting. More recently also, Mr. Arthur Rigg, of Chester, has proposed and used a form of continuous indicator, which, although possessing one or two minor advantages over Mr. Gooch's, appears to us to be open to far more serious objections than the latter. According to Mr. Rigg's plan the cylinder of the indicator is placed in

communication with the engine cylinder at brief intervals, the communication being allowed to remain open for, say, three revolutions out of every hundred; while the pencil carried by the piston-rod of the indicator bears against a strip of paper, which has a slow motion imparted to it by convenient means. The effect of this arrangement is that during the time that the communication between the engine and indicator cylinders is shut off, the pencil of the indicator will trace an atmospheric line on the paper; but when the communication is open it will rise and fall tracing on the paper vertical lines, which by their length indicate the maximum steam pressure and vacuum in the cylinder. These data being registered, it is intended to calculate the power developed by the engine by working out indicator cards taken from the latter, and having maximum steam pressures and vacuums equal to those registered by the continuous indicator. This method is in any case a very roundabout one; but in instances where the boiler pressure is constant, or nearly so, and the speed of the engine is controlled solely by the throttle valve, it may be possible by some considerable expenditure of time and trouble to obtain by Mr. Rigg's plan a tolerable approximation to the power developed by an engine in a given time. So soon, however, as we have to deal with an engine having varying expansion, Mr. Rigg's system becomes useless, as it is evident that of two diagrams, both showing the same maximum steam pressure and vacuum, the one may, from an alteration in the point of cut-off, correspond to the development of twice or three times the power shown by the other. Under these circumstances the maximum pressures and vacuums registered by Mr. Rigg's instrument would, of course, be of no use whatever.

In the case of engines fitted with Messrs. Farey and Donkin's arrangement for measuring the amount of heat passing away in the condensing water, the power developed in a given time can, as we explained in a recent number (*vide* page 341 of our last volume), be ascertained with a great degree of accuracy soon as the "constant" of the engine is known—the power developed and the quantity of heat passing away being sensibly proportionate to each other. But even with Messrs. Farey and Donkin's system some calculation is requisite, and although as an accurate test of the performance of steam engines it may be considered practically perfect, it does not form a ready means, easily applicable in all cases, of ascertaining the total work done in a given time by any engine, however variable that work may be.

The only instrument yet brought under our notice which satisfactorily fulfills this much to be desired end, is the steam power meter and continuous indicator lately designed by Messrs. Ashton and Storey, of Manchester, and which to our minds was the most interesting scientific novelty exhibited at the recent show of the Royal Agricultural Society. In this apparatus a modification of the inte-grating arrangement employed in General Morin's well-known dynamometer has been used to multiply the motion of the piston by the pressure exerted upon it, the result, expressed in foot-pounds, being by suitable mechanism indicated upon a dial. The general arrangement of this ingenious instrument is shown by the engraving which we publish in the present number, and we trust that the explanation of its construction there given will render its action clear. We believe that this instrument will be found to render material aid in estimating the economical value of different engines under various circumstances, and it will at once show whether any unusual expenditure of fuel is due to increased work thrown upon the engine or to carelessness upon the part of the attendants. It will also enable the user of the steam engine to ascertain, by mere inspection of the dial, the power required to drive different machines, or the efficiency of different lubricators, and it will furnish a variety of similar information, the value of which will be fully recognized by those who have hitherto only been able to obtain it by a considerable expenditure of time and trouble. Altogether we regard Messrs. Ashton and Storey's invention with much interest, and we shall carefully watch its progress. We shall be especially glad to know that it can be used on locomotives without the vibration giving rise to defective indications, and we trust that but a short time will be allowed to elapse before it is fairly tried under such circumstances. Once let it be proved that Messrs. Ashton and Storey's steam power meter can be depended upon to register accurately the actual work done by a locomotive during any given run, and those of our railway engineers who are inclined to make experiments, will have plenty of useful work on their hands for some time to come.

DESIGNOLLE'S NEW POWDER.

By A. Payen.

From "Bulletin de la Société d'Encouragement," through Polyt. Journal.

The introduction of the breech-loading ordnance and arms is a great progress in the art of warfare. But it is not less important to improve the moving agents and the moving power for projectiles, and to invent new kinds of gun-powder, the action and energy of which might answer the various wants of modern artillery.

The importance of this question was fully understood by Designolle, who, after incessant experimenting for seven years, seems to have arrived at its practical solution. In considering the actual condition of artillery it is evident that four principal kinds of powder are required:

1. Gun-powder.
2. A quick-acting powder for short-bore cannons.
3. A slow-acting powder for long-bore cannons.
4. A blasting-powder for torpedoes and exploding projectiles.

The ballistic power of the powder used heretofore, cannot be increased by altering the mixing proportions of its constituents.

The initial velocity imparted to the projectiles by the ordinary black gun-powder has been somewhat increased by the improvement of the machinery, by which the materials are prepared and mixed in the manufacture. This has been effected especially by the use of grinding-mills instead of stamping-mills. But the explosive or blasting power, which is injurious to fire-arms, has been increased by this change much more than the shooting-power.

The principal advantage of Designolle's system of powder-manufacture consists in the possibility of producing a whole range of different kinds of powder, varying in strength, and designated by different numbers, from 1 to 10, according to their strength. Also two entirely different classes of powder can be made by this system, a blasting-powder, the strongest kind of which is ten times more powerful than an equal weight of the powder now in use, and a gun-powder whose shooting-power is equal to that of the ordinary black powder, its explosive and destructive effect being however considerably less than that of the latter.

As either of these two classes contains ten numbers, differing in strength, it is evident that the system can answer any requisition.

Designolle has solved the problem of manufacturing a powder, the different kinds of which are suitable for different lengths and diameters of the bore of fire-arms and for different weights of the projectiles, and imparting to the projectiles an initial velocity as desired and as determined beforehand.

One principal constituent of Designolle's powder is picrate of potassium. The blasting-powder contains besides this only nitrate of potassium. The gun-powder is a mixture of picrate of potassium, nitrate of potassium and charcoal. These substances are mixed in different proportions, according to the strength required.

Picrate of potassium is composed of picric acid and potassa. Picric acid is a substance which was first discovered by Haussmann, in 1788. Welter afterwards obtained it by treating silk with nitric acid. A number of French and German chemists have made researches on the same substance. But it was reserved to Laurent to find out its exact composition and chemical formula, and to discover the most proper way of making it. He showed that the picric acid corresponds in its composition to phenylic acid, in which three equivalents of hydrogen are replaced by three equivalents of hyponitric acid.

$$\text{Formula: } C^{12} \left\{ \frac{H^3}{(N\,O^4)^3} \right\} O$$

A Paris gas company produces on a large scale phenylic acid which is the principal raw material for the manufacture of picric acid and of its compounds.

Picrate of potassium is a crystalline compound, consisting of small, glossy, yellow prisms of the dimetric system. It is insoluble in alcohol, very little soluble in cold water; but it can be dissolved in 14 parts of boiling water. When heated carefully to 300 degrees Celsi, it becomes orange. It, however, retakes its original color in cooling. When heated to 310° C. it explodes with vehemence.

This substance was very dear until lately, when John Casthellaz, one of the best French manufacturers of chemicals, improved its manufacture to such a degree, and produced it at such a low cost that the price of Designolle's new powder is but very little higher than that of the ordinary black gun-powder. To be able to determine the quantity of saltpeter and charcoal to be mixed with the picrate of potassium, it was

necessary to examine the chemical reaction which takes place when this substance is made to explode. Designolle found, by numerous experiments, that two entirely different reactions can take place according to the circumstances under which the substance explodes.

1. When picrate of potassium explodes in the free atmosphere, prussic acid and nitric oxyde are formed.

2. When picrate of potassium explodes in a narrow place, as for instance in the bore of a gun, neither prussic acid nor nitric oxyde are formed, but the products are in this case: nitrogen, carbonic acid, hydrogen, oxygen, carbonate of potassium and carbon.

The formula which expresses the latter reaction, and on which the manufacture of the powder is founded, is as follows:

$$K\,O + C^{12}\left\{\frac{H^2}{(N\,O^3)^3}\right. = 3\,N + 5\,C\,O^2 + 2\,H + O + K\,O, C\,O^2 + 6\,C.$$

Designolle's powder is made in the following manner. The different substances are at first mixed with 6 to 14 per cent of water, and crushed fine in a stamping-mill. Three to six hours are required for this operation. The mixture is then compressed in a hydraulic press. As the rapidity with which the powder burns or explodes is in an inverse ratio to the pressure to which it has been subjected, this pressure is taken differently, according to the different use to be made of the powder under treatment. This pressure varies from 30,000 to 100,000 kilograms. The compressed mass is corned by a special machine, sifted, polished and dried. The last two operations are done in the same way as with ordinary black powder.

There is, with the above exception, no difference in the mode of manufacture of the various classes and kinds of Designolle's powder. The proportions of the materials only are different according to the qualities that are required for the different kinds. The greater the amount of picrate of potassium in the mixture, the greater is the ballistic power of the product. Gun-powder ought not to contain over 20 per cent of the picrate. From 8 to 15 per cent of it are used for making cannon-powder, the exact quantity depending on the rapidity and vehemence with which the powder is expected to explode.

The advantages which Designolle's powder has over the ordinary gun and blasting-powder are the following:

1. Its ballistic or shooting-power can be increased without increasing its explosive force.

2. The strength of the powder can be exactly regulated within the limits given by the numbers 1 and 10.

3. The rapidity of action of the powder can also be exactly regulated.

4. The ballistic power of the powder can be increased without altering the mode of manufacture and in using similar materials.

5. The effects of the new powder are very regular and uniform. The initial velocity of the projectiles thrown by one kind of this powder is always the same. This velocity varies with different kinds from 1 to almost 2 meters, according to the mixture and pressure employed in the manufacture.

6. The new powder does not contain any sulphur, so that no vapors of sulphide of potassium or of sulphide of hydrogen are produced by its combustion, which vapors are very injurious to the health of the men when working in a casemate or in the interior of a man-of-war.

7. From the same reason the new powder has no injurious effect on iron, copper or brass.

8. The smoke produced by the combustion of the new powder is but very slight, and is in fact nothing but steam with small quantities of carbonate and oxyde of potassium.

Large quantities of Designolle's powder are actually manufactured in the French Imperial cannon-foundry at Bouchet; gun-powder as well as quick and slow-acting cannon-powder, and blasting-powder for torpedoes and for explosive projectiles. S.

METALLIC TUBES.—A new and promising industry is announced, that of the manufacture of metallic tubes from rolled plates, by machinery. The resources of the tube drawer have not been called into requisition for the production of stove pipes or speaking tubes, nor is it perhaps necessary that they should be. Heretofore they have been made cheaply by hand. We shall next week illustrate and describe a simple continuous machine whereby these and other varieties of tubes may be made, at almost insignificant cost for attendance, at the rate of sixty feet per minute. They are made from flat strips or skelps, with a continuous, longitudinal joint, wherein two continuous edges are lapped and locked together by pressure

only. If the statements of the patentees may be fully relied upon, small (1-inch) copper tubes made upon this plan have withstood a pressure of 250 lbs. per square inch without leaking, and tubes of iron, zinc, tin, &c., considerable although less pressures. The joint can be formed either inside or outside of the tube, so as to present a flushed surface on either side as required.

Supposing such results to be fully established by continued practice, it is a question whether surface-condenser tubes could not be made with advantage by the same process. Some of the larger surface condensers, as those of the Hercules, have upwards of twenty miles of small, say, three-quarter-inch tubing. The pressure within them, where the steam is admitted to the outside, does not probably much exceed 25 lbs. per square inch, say 12½ lbs. due to the vacuum, 5½ lbs. for the head of sea-water above the condenser, and 7 lbs. for the force required to pump through the circulating water. Should there be the least leak at any point, the leakage would be of sea-water, charged, of course, with whatever air might be in mixture with it. It is a nice question, only to be settled by experiment, whether there would be any leakage, in tubes thus made by machinery, and subjected to a pressure of 25 lbs., and, if so, whether the leakage would be such as to materially vitiate the vacuum. If a tube should leak, it is not only a difficult matter to replace it, but it is even more difficult to find it among from 3,000 to 7,000 others. So far as a little leakage of salt water is concerned, it is by no means objectionable when it is considered that a little salt water is the very thing wanted at intervals in boilers working with surface condensers. If the salt water does not enter the condenser, it has now and then to be pumped in from the sea. In the latter case, however, the supply is known, and under control, while in the former it may be anything or nothing.

If mechanically jointed tubes should be found available for surface condensers, as possibly they may be, it will be urged that the laps of the joints represent so much excess or waste of metal, and that the rolled metal, with which the process commences, must cost more than the cast metal employed by the tube drawer. It will remain to be seen how much thinner metal may be employed in rolled plates than that to which tubes of the same strength may be drawn, and there is again to be considered the great economy of manufacture in the new process as compared with the slow and tedious process of drawing. We intend to offer no opinion upon these points, but to await the results of careful experiment, results which will probably be soon forthcoming. The members of the Institution of Mechanical Engineers are likely, we understand, to have an opportunity of seeing the machine at work during the approaching meeting at Newcastle, and we shall, as we have said, illustrate and describe it in our next number. It is the invention of an American, and is being introduced into England by Mr. T. F. Taylor, of No. 9 Doughty-street, Mecklenburgh-square, and 42 Kirby-street, Hatton-garden.—*Engineering.*

THE HIGHWAYS OF NATIONS.

From "The Engineer."

With the introduction of steam, and its application to locomotives and marine engines, came the race between land and water, which should constitute the principal routes of international communication. So far as the actual distance between any two emporiums of traffic and commerce is concerned, the land has the advantage of the water in the ratio of three to one. In other words, a journey by land of three hundred miles could be accomplished by rail in the same time as one of a hundred miles by water, even supposing our fastest ocean going steamers performed the voyage. The odds are still further increased in favor of land journeys if we take into consideration the general disinclination of passengers to sea voyages, and the troubles, delays, and anxieties that are the inevitable accompaniments of those that "go down to the sea in ships." These objections do not apply with the same force to the transport of merchandise, but they are not completely invalid even in that instanee. The difference between ocean highways and similar inland routes may be briefly expressed by saying that by the former we go round the world, by the latter we go across it. A glance at the map of our own little island is sufficient to demonstrate this fact, but to appreciate it fully, and to apply the simile upon a scale of magnitude commensurate with our title, we must lay before us the railway maps of Asia and America. There we see lines stretching from coast to coast, traversing deserts, forests, and prairies, and uniting opposite seas by a medium of communica-

tion not their own. In India, the port of Beypoor, on the west, is linked to that of Madras, on the east, by a railway which runs right across the southern portion of our oriental peninsula, and Bombay and Calcutta, the city of palaces, will soon be *en rapport* by the same means. But these, and other great national arteries of commerce and civilization, sink into comparative insignificance before the gigantic chain which now stretches from New York to San Francisco. If the status of our own country reached its climax almost before the introduction of what are now recognized as the pioneers of civilization, what must be the future of the new world where the same advantages have throughout the greater portion of its vast extent preceded the advent of the population?

To unite country to country, nation to nation, and continent to continent, by a more intimate link than ever previously existed, is the mission of the age; and insomuch as the common interests of the last exceed those of the former, so much the greater is the merit due to the accomplishment of the union. As an example of our meaning, the Mont Cenis tunnel will effect the union of France and Italy, and, without indulging in metaphor, undermine the glory of both Hannibal and Napoleon. But this is but a link, locally considered, between two adjacent countries, whereas the piercing of the Isthmus of Suez accomplishes a more direct communication between Asia and Europe than the two continents have ever previously enjoyed, and constitutes in every sense a highway of nations. It might be supposed that those ports and towns forming the termini of a route of this nature would benefit more largely than others situated more remotely from its vicinity. To some extent this supposition is correct, but not to the degree usually assumed. It is impossible at the present time for one nation to become rich at the expense of another, or to benefit exclusively by the magnitude of its imports. The days of national monopoly are gone, never to return. Increase of imports signifies increase of exports, and it is only now by an interchange of traffic and commercial relations that a country can hope for a prosperous future. Projected, advocated, and carried out by a Frenchman, it would be but a fair return for his nation to reap the most substantial advantages from the maratime canal. May it be so, the more especially as we are perfectly convinced that any stimulus and increase that may be given to the trade of our neighbors will not fail to be nearly equally valuable to ourselves. At the same time it is well not to be over confident. Disappointment is ever in direct proportion to expectation. Will the hopes of our Gallic friends be fully realized?—Will the results equal their anticipations? Will the opening of the new route restore to the old "highways" their former traffic? Shall Venice rise to her pristine glory, where she "sits enthroned upon her hundred isles?" Shall the lion of St. Mark again be the lord of the Adriatic? and shall the merchandise of India and Asia be wafted to the ports of the Mediterranean?

In former times a sailor who had doubled the Cape was regarded as a tried navigator, and considered competent to give his opinion and hold his own views with his nautical *confrères*. The scientific manner in which vessels are handled at the present day, and the large increase of steamers, have in some measure destroyed the value of the old test, but still rough weather is generally looked out for near that locality. Practically speaking, the value of the Suez Canal to the sailor is that, if successful, it will obviate the necessity of the passage round the Cape of Good Hope, and reduce the length of the voyage nearly one-half. The junction of two seas that is effected by the Suez Canal has long been endeavored to be accomplished in the regions of the new world. No less than seven different lines of canal have been projected and roughly surveyed in order to discover a highway between the Atlantic and Pacific Oceans. The value of such a work did not escape the penetration of the great adventurer and discoverer Hernandez Cortes, but from his time until now, with the exception of a railroad across the Isthmus of Panama, the communication has remained *in statu quo*. A ship canal in this situation would open a new route to Australia, China, Japan, and the adjacent countries—would do away with the passage round Cape Horn, and be an invaluable benefit to the commerce of the two hemispheres. At present it appears to be an impossibility to construct this important channel without the intervention of several locks. These would be fatal to the enterprise, as to attempt to pass the traffic of the world through a number of locks is an absurdity which the most reckless speculator could not ignore. Important as some of the routes are to which we have briefly alluded, they are nothing to

those which remain to be opened up. China is still a country where the "iron horse" has never run. The boundless plains of Thibet and the wilds of Tartary, in their almost immeasurable expanse, are ignorant of steam locomotion. The great Asiatic highroads have yet to be delineated by lines of iron; the caravan must be replaced by the railway carriage, and the canal by the engine.

CONCRETE BUILDING.

Mr. Goodwin, builder of a concrete warehouse in London, communicates to "the Builder," the following account of the structure and materials: The concrete is composed of one part of best Portland cement to seven parts of material consisting of clean Thames gravel, crushed slag and clinkers from furnaces, crushed bricks, stone chippings, oyster-shells, pottery, hard core from dust-yards, and any other hard and incombustible material I could get. We built upon an average per day about 12 in. all round the walls, grouting in with sand and cement at every fresh layer of concrete. We also put in hoop-iron bond at each floor. We could have built 18 in. per day, which is the depth of the apparatus, but I considered 12 in. quite fast enough for a building so high; though at other smaller jobs I have often built 3 ft. per day.

The building is 70 ft. by 50 ft., and 60 ft. high. It consists of basement and five floors, each floor supported by twelve iron columns. The roof is of concrete 3 in. thick, laid between tee-iron 3 ft. 6 in. apart, covered with asphalte. The thickness of walls is to the brick rule; those 70 ft., two floors 27 in., two floors 22 in., and two floors 18 in.; the 50-ft. walls are, two floors 22 in., and four floors 18 in. The cost of the walls, considering I got a great deal of the material for nothing, was under £6 per rod; or, take the whole of the building as a cube, the cost was about 3d. per foot. It is very strongly built, and as good as one of the warehouse class can be. It is now loaded with goods, every floor full, and has never shown the slightest crack or settlement. It is harder than most kinds of stone used for building purposes, and is of one solid mass from beginning to end.

As with Mr. Tall's patent apparatus (with which it was built) a perfect surface is obtained throughout, it requires only a thin coat of cement and sand to finish the walls perfectly smooth and true. I quite agree with Mr. I'Anson in his opinion "that the success of such work depends on the entire honesty of the man who does it."

I have learnt so much of concrete with this and other contracts I have taken since, that I find the greatest care must be used in choosing the material. I have made specimens of all kinds. Many persons, and amongst them builders, think if they have gravel, by adding the cement they have all that is required to make concrete. So much depends upon the gravel, that if it is not the right sort the work will cost as much as brickwork, and then never be sound. Every bit of loamy matter and dirt must be washed out thoroughly; then you must replace with clean sharp sand, about one-fourth.

Those who wish to build of concrete should only do so where the material is on the spot or very near. Clean river ballast, with a good proportion of sand, is as good a thing as we can have for Portland cement concrete. If some crushed slag or furnace clinkers can be mixed, so much the better; it is also lighter, which is a good thing in wall construction. Burnt clay is also a very good material, provided it is well burnt. Great care should be taken to sift with a fine sieve all crushed material; for, let it be what it may, dust, loamy matter, or fine sand, if it is finer than the cement itself it will dilute and kill it. I have made specimens of concrete with gravel that have become as hard as the best stock brick, and I have made others, with the same proportion of cement, that you may crush and crumble in your hands.

The concrete chapel I have just completed at Snaresbrook, in Essex, is built of the refuse of the brick-fields, mixed with sharp sand got from a good depth, there being a sewer in course of construction close by. The concrete is composed of one part cement to seven parts of material. The prime cost of the walls, including the working the apparatus, was £7 per rod. Many of the statements that have appeared in print upon concrete are not correct. It has to be borne in mind, a yard of concrete mixed dry, when wetted and put into the apparatus, falls considerably short of a yard,—at least 15 per cent. Neither does the cement make bulk, but disappears in measure, as does the water. If lumps of stone can be got, or brick burrs, or old bricks, to pack into the wall, it makes better work and cheaper. The more the cement can be displaced the better for the work and the less the cost.

Great care should be taken the cement is not too fresh, or it will cause the work to crack. It should be at least a month old before using.

The concrete villa at Addiscombe-road, Croydon, is now completed and occupied; it gives great satisfaction, and, it is said, will be the only house the rain will not penetrate in that neighborhood. The lower floors are all of concrete, and perfectly smooth and warm; there is no channel for a mouse or any creeping thing in that house, unless it take up its abode with the family.

THE SIEMENS-MARTIN PROCESS.

Abstract of a paper read by Mr. Richard Howson, before the Iron and Steel Institute.

After some remarks touching the history of the mode of manufacturing cast steel by melting certain proportions of cast iron and wrought iron together, the writer proceeded to observe that it was not till 1845 that the process assumed a practicable shape. In that year Mr. Heath obtained a patent, the specification of which clearly describes how such a process may be carried out in the hearth of a reverberatory furnace. We have no record that his experiments led to commercial success; probably there were difficulties in the way. At a later date other workers came into the field, and in the hands of Mr. Attwood the manufacture has reached a fair degree of certainty and excellence, to which the use of Siemens's furnace has doubtless in a great degree contributed. Meanwhile, in France, the Messrs. Martin were prosecuting experiments in the same direction and on the same principle as described by Heath, and were successful. Their method of proceeding, however, introduced some new features, especially the use of oxides. The staple trade of their establishment at Sireuil is the manufacture of gun barrels, which they turn out of excellent quality from pig iron and puddled ball, which are both the produce of a pure African ore. The process may be simply described as follows: The pig iron is first melted on the hearth of a Siemens furnace, in weight from ½ ton to 1 ton. The puddled ball (previously heated) is then added in quantities weighing about 1 cwt. at a time, with occasional small doses of oxide of iron of pure quality. By these means the carbon in the bath becomes gradually reduced to a low percentage, and the metal approaches to the state of wrought iron. A portion of the carbon is then restored by the addition of spiegeleisen, so as to give the steel the requisite temper, and the process is finished, and the whole is tapped off into ingot moulds. The ingots are subsequently hammered, rolled, and forged into gun barrels. The time occupied from charging the furnace to tapping out is about 11 hours, and the average proportion of cast and wrought iron will be about 2 of the former to 3 of the latter, with usually 2 or 3 per cent of oxides. At the Newport Works the experiments which have been made are very numerous. The next portion of the paper was devoted to a detailed description of the apparatus, and then went on: The rationale of the process next comes under notice, the state of the bath being judged of at different periods by means of tests which are from time to time taken out. After the pig iron is melted, the first action which takes place is the oxidation of the silicon. The fracture of the test is then white, like refined iron. As more wrought iron is added, it becomes more or less malleable, and the fracture assumes a dull, gray color, getting gradually brighter and more compact in grain, until it reaches the stage of true steel. At this point the process might be stopped, and has been stopped, with good results; but it is not always safe to do this in practice. The better plan is to proceed until the tests begin to bend and tear, and then to impart the requisite hardness by adding spiegeleisen, about 1 cwt. to the ton being usually a sufficient quantity, with brands containing 6 or 7 per cent of carbon. The experience at Newport has shown that little improvement is to be gained by deviating from the practice adopted by Messrs. Martin themselves, and it has also decided another question, viz: that the process offers little or no chance for the employment of low-priced iron. As a rule, the present brands produce the best ingots, and it is much to be regretted that Cleveland iron, except in the state of very carefully puddled bar, seems to be quite inadmissible. The author spoke favorably of the economy of the process and of the possibility of its standing the severe competition in England; and went on to notice two points of interest contingent to the process. In the first place, he said it had been found that when the bath had arrived at the soft stage, there was considerable danger in allowing it to remain any lengthened period before adding the spiegeleisen. As long as there was a sufficient amount of carbon in

both, it acted as a protection to the iron against oxidation; but when it was all, or nearly all burnt away, the iron itself began to burn, as might be seen by the crystallized appearance of the fracture. It was a question, however, whether it was the free oxygen of the flame alone which produced this result. Professor Graham had shown that carbonic oxide penetrated iron with extreme facility; and specimens were shown which had been subjected to the action of carbonic oxide under a variety of conditions. They all presented the same appearance of deteriorated structure; and were all excessively brittle. Neither carbonic acid nor atmospheric air under similar conditions seemed to have the same effect; and it might be fairly assumed that this question required further examination. The other point to which he referred was a peculiar property of homogeneous iron or mild steel, which was early observed in the course of the experiments at Newport. When ordinary steel was chilled in cold water at a red heat, it hardened more or less according to the percentage of carbon it contained. When the carbon was reduced below a certain amount—about 5 per cent—it then obeyed the same law as copper. The metal when chilled became soft to the file; but, at the same time, more compact, tougher, and stronger. Specimens were exhibited to illustrate this fact; and the question was glanced at as to the probability of hereafter turning this property to useful account. The writer concluded by stating that much remained to be done in the metallurgy of iron and steel; and ventured the prediction that steel ingots for rails would yet be made at a price but little exceeding that of puddled bar, although he acknowledged that whoever undertook to do it would have to bring to the task a large stock of patience, perseverance and capital.

THE STRENGTH OF BOILERS.—It has been found, by actual experiment, that good forged iron will bear a strain of from 25 to 30 tons to the square inch of section. That is, a bar one inch square, or a plate of iron containing one inch of sectional area, will require a force of from 50,000 to 60,000 lbs. to wrench it asunder. Some years ago, a committee of the Franklin Institute of Philadelphia very thoroughly investigated this question of the strength of boil rs, and it was found that the tenacity of boiler-plate increased with the temperature up to 550°; at which point the tenacity began to diminish. At 32°, the cohesive force of a square inch of section was 56,000 lbs.; at 570°, it was 66,500 lbs.; at 720°, 55,000 lbs.; at 1,050°, 32,000 lbs.; at 1,240°, 22,000 lbs.; and at 1,317°, 9,000 lbs.

Strips of iron cut in the direction of the fiber were found to be about 6 per cent stronger than when cut across the grain. Repeated filing and welding was found to increase the tenacity of the iron, but the result of welding together different kinds of iron was not found to be favorable. The accidental overheating of a boiler was found to reduce the ultimate or maximum strength of the plates from 65,000 lbs. to 45,000 lbs. per square inch of section, and riveting the plates was found to occasion a diminution in their strength of one-third. The results of M. William Fairbairn's experiments differed somewhat from the above. He found that boiler-plate bore a tensile strain of 23 tons per square inch of section before rupture; which was reduced to 16 tons when joined together by a double row of rivets, and 13 tons, or about 30,000 lbs., when joined by a single row of rivets (2,240 lbs., are allowed here for a ton).

Mr. Fairbairn says that "plates when riveted together are reduced in strength from the fact that nearly one-third of the material is punched out for the reception of the rivets," and therefore he takes 34,000 lbs. as equal to the strength of riveted plates containing one inch of sectional area.

In casting up the bursting pressure of boilers, it is necessary that some number representing the tenacity of plates one inch thick be decided upon. Some engineers in their calculations estimate it at 34,000 lbs. while others place it as low as 25,000 and 30,000 lbs. These figures suppose the iron to be of the best quality, and the following rules suppose the workmanship of the boilers to be first-class in every particular. No rules can be given for poor materials, nor for poor workmanship. By a sectional inch or an inch of sectional area is understood a sufficient surface of boiler-plate of any thickness under 1 inch to make a thickness of 1 inch; or, in other words, suppose a boiler to be constructed of $\frac{1}{2}$-in. iron, and from its end we cut off a section or hoop 1 in. long, two such sections would be equivalent in quantity of iron to one hoop 1 in. thick, for the two being each $\frac{1}{2}$-in. thick would together be 1 in. thick. If the boiler was constructed of $\frac{1}{4}$-in. iron, it would require

four such sections to make one an inch thick. If constructed of ⅜-in. iron, 2.66 would be required, and so on for any thickness of plate. In testing the strength of iron, bars 1 in. square are used; hence, in estimating pressure on boiler-plates, sufficient surface must be taken for each thickness to equal in quantity a bar of iron 1 in. square. If we assume that single-riveted boilers will sustain a tensile strain of 34,000 lbs. per square inch of section before rupture, the strain on each superficial inch on a plate ⅜-in. thick would be ⅜ of 34,000, and for ¼-in. plate ¼ of 34,000, etc.—*The Locomotive.*

BETTER IRON RAILS.

We promised in a previous number some facts about the superior durability and economy of thoroughly worked iron in rails, and the practicability of obtaining good rails at a reasonable cost. The case of the Reading railway, to which we intended to refer, and the whole issue between railway managers and rail makers, is thus stated in the New York "Times."

Whenever a broken rail throws off a train or the enormous cost of maintaining permanent way is under discussion, there is a general outcry against the poor iron of modern production, and a longing for the skill, science and honesty among manufacturers that used to make rails last twenty years. Nothing can be more touching than the pious regrets of a railway manager, standing among the *debris* of rails, axles and machinery worn out in the flower of their youth, at the degeneracy of the metallurgical skill and conscience of the period. In order that the public may understand how far their risks of life and loss of dividends are due primarily to this cause, we invite their attention to the following facts and considerations.

The general rule in this country (to which there are indeed exceptions) in regard to the purchase of railway materials is simply this: buy the cheapest. First cost is the controlling and often the only question entertained. The nature of the materials and processes to be used in the manufacture of rails, for instance, are not mentioned. The buyers for some of our roads, especially new roads, never make the slightest allusion to quality, and never specify tests and inspections, but simply go about among the mills, comparing and beating down prices, and accepting the very lowest. More than one of our rail makers are to-day rolling, under protest, rails upon which they decline to put their trade-mark—rails made from the very cheapest materials, in the very meanest manner—for all that is required is that they shall stick together till they are laid. And if American makers will not roll them, Welsh makers will. The late report of the State Engineer of New York says: "American railway managers, instead of offering anything like a reasonable price for good iron rails, have made themselves notorious by establishing as standard, a brand of rails known all over the world as 'American rails,' which are confessedly bought and sold as the weakest, most impure, least worked, least durable and cheapest rails that can be produced." The State Engineer refers in confirmation of this opinion to the statement of Mr. A. S. Hewitt, United States Commissioner to the Paris Exposition, a statement not yet controverted; and to a statement of Mr. Sandberg, an English engineer of note, in the London *Times*. A leading American railway president and reformer has publicly said: "There is a fear on my part that railway companies will themselves tempt steel-makers to send a poor article by buying the cheapest—first cost only considered—*as they did with the iron-masters.*"

There is also a class of railway managers who pretend, and possibly believe, that they cannot get good iron rails—that the existing processes for cheapening iron in all stages of its manufacture render it impracticable to produce the uniform and excellent material formerly made. Now, while it is true that much poor iron is called for and sold, it is notorious that a better knowledge of chemistry and the modern improvements in machinery enable iron-masters to produce a more excellent and uniform material than ever before, as well as to reduce its cost.

These general facts are well enough known to those who have taken the trouble to inquire. But we are not confined to general facts. There are particular cases that cover the whole issue. The one we shall mention now is, fortunately, of such a character that no private interest can affect the statement or be affected by it. Early in 1868, the Reading Railway Company commenced rolling their own rails by an improved method, and some of them have already been down long enough, under the immense coal traffic of that road, to vindicate this policy. For instance, out of 9,000 tons of home-made rails, which had carried a certain traffic during the last nine months of 1868, only five

tons, or one in 1,800 tons, had worn out. During the same time, and under the same traffic, out of 2,000 tons of rails made by the old process at an outside mill of good repute, about 200 tons, or one in ten, had been worn out and removed, and the indications are that the remaining 1,800 tons will be unfit for use at the end of this year. At a point in the road near Reading, where shifting from connecting lines is added to the regular tonnage, the life of rails made by the various old processes is from three to four months. Some rails only last six weeks. At this point the rails made by the new process have already been down sixteen months and are still sound, although much worn. The trouble with ordinary iron rails, as we have explained on another occasion, is that they go to pieces before they get a chance to "wear" out.

The best iron rails cost perhaps twelve to fifteen dollars per ton more than the poorest, but if they last twice or thrice as long, no railroad manager will pretend to doubt their economy. The trouble is, that some railroad managers, and especially the builders of new roads, never consider the question of durability. Nor is there any secret or difficulty in the manufacture of good iron rails. One process, which makers are sometimes forced into by low prices, is to cut up old rails, pile them together and roll them into slabs to form the head of a new rail. The remainder of the pile from which the new rail is rolled, is simply old rails cut up and laid together. Not a particle of new iron, which would greatly help the welding, is added, for that costs some six or seven dollars per ton more than old rails; and not half work enough is done on the loose bundle of iron forming the rail pile to compact it. Nothing is more certain than that such rails will go to pieces in the welds after short service. The method adopted by Mr. Coxe, of the Reading Railway Company's mill—and the same or a better one would be gladly adopted by private makers if companies would pay for it—is as follows: Some 70 per cent of old rails and 30 per cent of new iron (puddle-bar) are laid into a pile and rolled into slabs an inch thick. Nine thicknesses of these slabs are again piled, reheated and rolled into a headpiece two inches thick, which forms the top of the rail pile. The remainder of the pile is made up of seven thicknesses of the slabs before mentioned, the whole being heated and rolled into a rail.* In this way the body of the rail is twice compacted by heat and pressure, and the head, that receives the direct action of the car-wheels, is three times subjected to this condensing operation.

A rail thus made, instead of being a bundle of heterogeneous laminæ stuck together by cinder, and ready to split apart under the hammering of wheels, is a dense, compact, and comparatively homogeneous mass, which offers resistance not only to abnormal splintering, but to normal abrasion and wear, just in proportion to the work put upon it in the rolling mill. It is the perfect homogeneity of steel that enables it to outlast the best iron, even more remarkably than the best iron outlasts the poorest; and the nearer iron rails approach in structure to steel rails the longer will they last, and the less will they cost in the end.

It is time that this pitiful talk about the impossibility of getting good rails was stopped. There is no doubt that some railmakers "scamp" their work—a peculiarity of the period not confined to rail-making—but the worst of them can and will make good rails, if railway managers will give them a chance and institute suitable tests and inspections.

THE WERDER RIFLE.

Translated from "Polyt. Journal," by DARAPSKY.

The Bavarian government has proposed to the Chamber of Deputies to adopt the Werder rifle, together with the Berdan cartridge, for use in the Bavarian army, and to order for the present 100,000 of them. A Berlin military periodical contains the following description of the rifle mentioned: Werder's rifle is a breech-loader, simple in its construction and of small caliber (11 mil.).

The breech-mechanism has some resemblance to that invented by Peabody. The breech-block moves on an axle passing through to back part of the block at a right angle to the bore of the gun. When the breech-block is turned downwards, the breech opens, when turned upwards, it is closed. The Werder breech-block has a forked projection behind its axle. A concavity on the upper surface of the block receives the cartridge in loading.

The extractor has the shape of a joint-lever and takes hold of the cartridge from two opposite sides. The breech-block, in being turned down, sets the extractor in

* The pile is repeated after being reduced to 5×6¼. —ED. V. M.

motion. A spring brings the latter back in its ordinary position. The striker is situated within the breech-block, and is retained there by a spiral spring, which also draws the striker back after each discharge of the rifle. A feature which distinguishes the Werder system from that of Peabody is this, that the breech closes of itself when the rifle is cocked. Before this is done, the breech is kept open by a double spring attached to the above-mentioned forked projection at the back of the breech-block. During and after the discharge of the rifle the breech is kept closed by a support on which a projection at the front part of the breech-block then rests. When this support is removed the breech opens again. This support is movable round the same axle to which the trigger is attached, its motion being however independent from that of the trigger. The motion of the support is effected by an arm which passes through the trigger-plate, and which ends in a finger situated within the trigger-guard in front of the trigger, but bent in an opposite direction.

The lock consists of the following parts: the cock, the main-spring, the trigger with the sear, and the trigger-spring. The cock moves within a slot in the back part of the breech-block. The thumb-plate is on the right side of the lock.

When the cock is being made ready for shooting, an arm connected with it and provided with a small roller, pushes the breech-block upwards, thus closing the breech.

All the axles rest on the two parallel cover-plates of the lock. The whole mechanism is contained in a quadrilateral case screwed on to the barrel. The same screw which holds the trigger-guard in place, also serves to fasten the breech-mechanism to the case.

The whole mechanism, above described, works in the following manner. When the rifle is cocked, the breech closes of itself. When the trigger is pulled, the cock acts on the striker, and the latter on the priming. After the discharge of the gun, the breech is opened by a slight forward movement of the index of the right hand. By this movement the index leaves the trigger and touches the finger of the arm connected with the support of the breech-block. The support is turned off, and the breech-block sinks down, owing to the action of the double spring attached to the forked back part of the block. Thus the breech is opened. At the same time the extractor is set in motion by its own spring, and the case of the cartridge is removed. All this is done in one moment, during the short time when the shooter takes the rifle down from his cheek. The new cartridge laid into the concavity on top of the breech-block then slides into the barrel. In cocking, the breech closes again, and the rifle is ready for shooting.

The rifle being in this condition, a pressure applied by mistake on the finger of the arm connected with the support, would not be of any consequence, because the support is then kept in place by a projection of the cock, provided for the purpose. This arrangement prevents the breech from being opened prematurely. If required, the lock can be set at rest. For the use of this rifle the following manipulations are necessary:

1. Pulling the trigger.
2. Opening the breech, which is done by a slight movement of the index.
3. Introducing the cartridge.
4. Cocking.

If it is intended to keep the breech closed after the discharge of the rifle, the finger connected with the support of the breech-block has to be left untouched.

To draw the charge, the cock must be relieved slowly and carefully. After this the trigger is pulled, the breech opens and the cartridge is thrown out of the barrel, through the action of the extractor.

To take the lock apart, the screw of the trigger-guard is removed, the breech-mechanism is lifted out of the case, the left cover plate is taken away. After this the lock is free, and the three springs and the other parts of the lock may then be removed without the use of any kind of instrument or tool. The stock of the rifle is one piece of wood, and has a rectangular recess to receive the lock. The weight of the whole rifle is $8\frac{1}{2}$ Zoll lbs. (1 lb. $= \frac{1}{2}$ kilogram). Its length is 50 inches of Rhenish measure. The rifle is provided with a sword-bayonet, and with a stairs-sight. The cartridge is pressed from copper with a central prime. It has been designed by Uttendörffer, at Nuremberg. 4.3 grams of powder are used for a shot. The projectile is partly cylindrical with two channels; it is oval in front and has a cavity behind for expansion. It weighs 22 grams. The case of the cartridge is conical. A coppered-iron plate of a somewhat larger diameter than that of the case, is soldered to it, and serves as a hold for the extractor. A ring of thick paste-

board is placed on the bottom of the case, inside. A small cup of brass containing the cap, and a small piece of brass is situated in the middle of this ring. It is to be seen from this description that this cartridge is a combination of Boxer's priming arrangement and of the American case-construction.

The Werder rifle, owing to the simplicity and ingeniousness of its construction, can be fired in rapid succession. The manipulations necessary for shooting cannot easily be more simplified and shortened by any other mechanism imaginable.

Well exercised soldiers have fired 14–15 times per minute, when they had to take the cartridges from their pouches. First-class riflemen at Amberg have fired 18 times in one minute, hitting each time the target, the latter being 4 ft. wide, 9 ft. high, and placed at a distance of 200 paces. A considerable advantage of Werder's rifle is the great facility with which the lock may be taken apart, a facility which every rifle for military purposes ought to possess. The whole construction is perfectly solid and strong, thus excluding all danger or mishap from breakages. These and other remarkable qualities of Werder's rifle and of the cartridges used with it, as well as the results of experiments made with both, are set forth in the military periodical of Berlin, all of which show that this rifle is one of superior excellence. S.

THE FIELD GUN OF THE FUTURE.

From the "Army and Navy Gazette."

Have we yet got the gun of the future—the gun that is to supersede all other weapons of its kind, which all men, be they Segmentites or Shrapnelites, followers of Boxer or believers in Armstrong, will acknowledge to be perfection, and join together in praising? The experiments in field artillery at Dartmoor have at length come to an end, and although the report of the committee is yet unpublished, not a little information respecting the results of the various trials has found its way in print. That much has been gained by these many experiments towards the solution of certain broad questions in the artillery science, there can hardly be a doubt, but that the information will, or can, be so condensed as to point out exactly what is needed for our field artillery we take leave to doubt. Even on the question of field artillery equipment for India it is difficult to arrive at anything like a definite conclusion, so many are the conflicting opinions on this head. During the recent experiments at Dartmoor, about 800 rounds were fired from their muzzle-loading bronze guns without drawback or accident of any kind whatever. The opinion of the committee, however, seems greatly in favor of a bronze field howitzer, as being a most desirable piece of ordnance for service. If we mistake not, the Indian artillery had formerly two howitzers in every field battery, and, although lighter than those now recommended, they were found to be most useful throughout all our great Eastern campaigns. The Russians have lately adopted bronze guns for their field artillery, and have also introduced a most formidable field howitzer of 6-inch caliber. The opinion of many Indian artillery officers seems to be in favor of a similar piece of ordnance being adopted in our own service, the more so as it would be attended with very little expense, there being numerous old smooth-bore bronze guns lying idle at Woolwich, which could very easily, and at a small cost, be converted into field howitzers. Whether any special recommendation on this head will be made it is impossible to say, but public opinion—that is artillery public opinion—goes far to make us think that for India the future field artillery will consist of muzzle-loading bronze 12-pounder guns, each battery having attached to it at least two formidable field howitzers of 6-inch caliber.

The science of field artillery, like that of every other military arm, is no doubt progressive, and is now in a state of transition. When infantry soldiers are armed with rifles that can hit a target the size of a man seven times out of ten at 1,000 yards, and when the men who handle those arms are gradually being trained to shoot with even greater precision, it is quite evident that field artillery must improve vastly both in the distance and exactitude with which it can do execution; otherwise every battery would be simply at the mercy of the first regiment of infantry that was pleased to make a target of the artillerymen, their horses and their guns. The experiments at Dartmoor have really proved the first preaching, so to speak, of this new artillery doctrine. The British public are very proud of their artillery, and have good reason to be so. But the said public is very much given to applaud what is, in these days at any rate, exactly the opposite of useful in

artillerymen as gunners. To see field batteries galloping about, changing their front and opening fire with the most wonderful rapidity—limbering and unlimbering their guns with a quickness and a dash that seems wonderfully expert to all unmilitary men, are what the spectators delight in at re views, and what give special correspondents occasion to praise greatly that of which they really know nothing. All this is pretty, looks well at Wimbledon or Aldershot, but it is not the real work of artillery. And this is the Dartmoor experiments, and more especially the report that will follow these experiments, must go far to dispel. Artillery ought certainly to be brought quickly into action, but once in action they ought to be in no hurry, and should remember that one round well placed is worth more than a dozen that have been fired at random. In a word, to use effectively field artillery the greatest calmness and precision is requisite. The first duty of the officer commanding a battery brought into action, is to ascertain his exact distance from the enemy. At Dartmoor many experiments as to the best means of working out this problem were made, but without any definite conclusion being arrived at. Some officers are in favor of telescopes being attached to the guns, others against the system; but there appears to be but one opinion respecting the necessity of instructing the gunners far more exactly than hitherto in the science—for it is a science —of judging distances correctly.—In a word, the Dartmoor experiments have proved that our field artillery must be exact, and that less care may be given to ensure dash, if more is given to create precision. They have also shown that we want a heavier field gun and more field howitzers than at present. In these days a campaign is finished in a week, and the times when a general could afford to halt for two or three days in order that his siege artillery might reach him, are gone forever. That, as yet, we have not the field gun required for service in these days of breech-loader rifles is very certain, and that we cannot afford to throw away the various guns we have made during the last ten years, is equally sure.—The Dartmoor experiments have at any rate taught us in what we are chiefly wanting in field artillery, and to learn this is something. But they have also shown very plainly that more deliberation, more experiments, and a considerable amount of patience are requisite before we can congratulate ourselves upon having found out the gun of the future, about which, before we begin to make it, let there, in the name of economy, be no doubt whatever. We have fallen into not a few ordnance pitfalls; let us beware lest we tumble into any more.

HYDROSTATIC STEERING APPARATUS.

From the "Mechanics' Magazine."

In designing the hydrostatic steering apparatus of H.M.S. Achilles, Admiral Inglefield has taken advantage of that great natural power which every floating vessel carries with it, viz.: the hydrostatic pressure of the water which sustains it. He thus has at his command an agent ready to be brought into action at a moment's notice. In such a vessel as H.M.S. Achilles, the pressure of the external water amounts to a load of about 8 lbs. per square inch at the level of the working cylinder, viz.: on the floor of the screw alley or the tunnel through which the screw shaft is conducted to the stern of the vessel. To move such a mass as the rudder of the Achilles against the resistance of the water when the vessel is going at 14 knots per hour requires very considerable power, and the problem to be solved was how to utilize the constant pressure of 8 lbs. per square inch, magnifying it so as to obtain sufficient force to overcome the resistance of the rudder. We will describe the manner in which this is effected by the Admiral, remarking that similar machinery may be adapted to any vessel.

A large cylinder, fitted with a piston and slide valve like that of a steam engine, is fixed horizontally in the lowest available part of the vessel. The external water is admitted to this cylinder through a Kingston valve guarded by a sluice valve. A powerful water engine is thus formed, ready to be set in action as occasion may require. Special arrangements for working the slide valve with unfailing certainty have been applied. A barrel is fixed at each end of the cylinder, and the piston rod extending on either side of the piston works in these barrels, which thus form powerful hydraulic pumps. These pumps are connected by pipes with two hydraulic cylinders fixed one on either side of the tiller on the lower deck. The rams of these cylinders are connected together by a crosshead carrying a strong steel pin entering a block, which slides in a groove attached to the under side of the tiller. Thus the tiller can traverse its full arc

in either direction, while the rams move rectilinearly to and fro. The water in its course from the hydraulic pumps to the tiller cylinders passes through a valve box fitted with a regulating or directing slide. This slide is worked by a rod extending upwards to the wheel house on deck, and passing downwards to wheels on the lower decks, one of which may be on the screw alley far below the water line. The wheels are worked by hand like an ordinary steering wheel, one man moving them with ease. When the wheel is in its middle position the water is cut off from the pumps, but the two tiller cylinders communicate freely; thus the rudder is left free to right itself. By turning the wheel through one-third of a revolution either way, the water pressure is turned on to one or other of the tiller cylinders, and the rudder is put hard over to port or starboard as may be required. When the wheel is turned only half its stroke in either direction, the water is locked in the tiller cylinders, and thus the rudder is held fast in the position to which it had been brought.

It will thus be seen that one man at either of the steering wheels does what it requires generally twenty-five men to do at the ordinary steering wheel. By means of the sliding block, acted on by a hand screw on the tiller, the hydraulic apparatus can be disconnected in less than a minute, and the tiller can thus be left free to be worked in the ordinary way; but this is not necessary, for by putting the directing slide in its middle position the tiller is left quite free, and can be worked by the ordinary steering wheels and tackle, which need never be disconnected. Thus the hydraulic steering gear may either act independently, or it may be employed as a force auxiliary to the men without in any way interfering with the normal condition of the steering apparatus. It may be readily understood from the construction that the working power acts only when it is wanted. When the rudder has to be moved, the hydrostatic cylinder or water engine acts. When the rudder is fixed in any position the water engine ceases to move, but remains ready to start into action the moment it is required with its full force. Our readers will now understand the general construction of the apparatus which has been found so successful in H.M.S. Achilles. We need scarcely say that there were numerous details of construction which required great consideration in applying it. The whole apparatus, however, is extremely simple, easy of application, and not liable to derangement from accident or wear. We understand that it is cheaper than any other mechanical steering apparatus yet tried. The power which it utilizes costs nothing, and is always ready to hand for use. These points, taken in conjunction with its success in the Achilles, should be the means of opening the eyes of the Admiralty authorities to its value.

DUROMETER.—An instrument for determining the hardness of metals has been invented by a French engineer. It consists of a drill, turned by a machine of a certain and uniform strength. The instrument indicates the number of revolutions made by the drill. From this, compared with the length of the bore-hole produced, the hardness of the metal is estimated. It is said that most rails are tested in France by this instrument.—*Steierm. Industrie u. Handelsblatt.*

THE "STONEWALL" DISASTER.—The question arises, what is the use of legislation, or of government, as far as the safety of passengers is concerned, when naked candles are allowed among bales of hay, when a vessel provided with the legally required pumps can incontinently burn up, when the boats and life-preservers certified to be sufficient and in order, do not save the passengers from drowning, and when the destruction is as complete as if there had been no life saving appliances at all?

It seems simply criminal on the part of those who have the power, to allow boat after boat, and their thousands of passengers to be destroyed by fire or collision, when the whole boiler power of the vessels could, if the proper pumps, injectors, or other *means of application* existed, drown any possible fire or neutralize any possible leak.

WORKING RESULTS OBTAINED AT THE NEUBERG BESSEMER STEEL WORKS.

BY G. KAZETL.

[As the Bessemer Steel Works at Neuberg, in Styria, are known as one of the best and most carefully managed establishments of this kind, we communicate in the following the working results obtained at these works in the years 1866 to 1869, as published in Oestr.-Zeitschrift, by G. Kazetl, special manager of the Neuberg Bessemer Department.]

I. *Materials Used.*

YEAR & HALF YEAR.	Pig-iron.	Steel scrap.	FUEL.							LINING MATERIALS.		
			FOR HEATING CONVERTERS AND LADLES.			FOR HEATING BOILERS.						
			Soft charcoal.	Coke.	Coal.	Wood.	Small coal.	Lignite.	Cinders from reverberatory furnaces.	Quartz.	Clay.	Bricks, tuyeres, etc.
	Cwt. (Austr.)		Fass.*	Cwt.		Cords.	Cwt.			Cwt.		
1866. I..	18,719 00	.....	3,083	1,892	.....	1,041	.....	.....	.....	1,283	343	382
II..	18,097 40	.....	2,550	3,014	.....	1,128	.....	.....	.....	1,179	316	81
1867. I..	25,843 70	.....	3,796	3,169	4	1,271	.....	.....	.....	1,826	453	142
II..	25,251 60	.....	3,170	3,636	.....	1,057	.....	.....	.....	1,535	402	117
1868. I..	32,136 90	.....	4,170	3,204	.....	1,360	.....	.....	.....	1,869	503	155
II..	31,413 10	15 45	3,350	2,520	52	395	1,079	7,780	2,353	1,709	436	199
1869. I..	31,575 60	345 35	2,672	2,715	134	.....	668	14,189	2,396	1,909	473	169

*1 Fass = 7.78 cubic feet. All the measures and weights are Austrian.

II. *Products.*

YEAR AND HALF YEAR.	Number of charges.	PRODUCT.			AVERAGE PERCENTAGES.			
		Ingots.	Scrap from pouring.	Scrap discharged from vessel.	Ingots.	Scrap from pouring.	Scrap discharged from vessel.	Loss.
		Cwt.						
1866. I.....	322	15,378 35	392 11	369 40	82.15	2.09	1.97	13.79
II.....	285	15,311 90	331 55	213 25	84.60	1.83	1.20	12.37
1867. I.....	385	21,847 25	352 15	494 75	84.53	1.36	1.91	12.20
II.....	362	21,599 90	315 15	586 75	85.53	1.24	2.32	10.91
1868. I.....	507	27,866 35	324 60	465 40	86.71	1.01	1.44	10.84
II.....	499	27,330 45	305 25	221 65	86.96	.97	.70	11.37
1869. I.....	495	27,635 50	161 05	174 45	86.57	.50	.54	12.39

III. *Materials Used on* 100 *lbs. of Ingots.*

YEAR AND HALF YEAR.	FUEL.							LINING MATERIALS.		
	FOR HEATING CONVERTERS AND LADLES.			FOR BOILERS.						
	Soft charcoal.	Coke.	Coal.	Wood.	Small coal.	Lignite.	Cinders.	Quartz.	Clay.	Bricks, tuyeres, etc.
	Cubic ft.	Pounds.		Massive cub. ft.	Pounds.			Pounds.		
1866. I.....	1.5	12.3	.....	4.8	.....	.....	.....	8.3	2.2	2.4
II.....	1.3	19.6	.....	5.3	.....	.....	.....	7.7	2.0	.5
1867. I.....	1.3	14.5	.02	4.2	.....	.....	.....	8.3	2.0	.6
II.....	1.1	16.8	.....	3.5	.....	.....	.....	7.1	1.9	.5
1868. I.....	1.1	11.5	.....	3.5	.....	.....	.....	6.7	1.8	.5
II.....	.9	9.2	.20	1.0	3.9	28.4	8.6	6.2	1.5	.7
1869. I.....	.75	9.8	.48	.....	2.4	51.3	8.6	6.9	1.7	.6

The manufacture of Bessemer steel was started at Neuberg in February, 1865, with one immovable Swedish converter and one revolving English converter of about 60 cwt. capacity each. It was intended from the start to use exclusively Neuberg pig-iron, and to run it from the blast-furnace into the converter without remelting.

The results obtained in the year 1865, have partly been published before this. The above tables contain the working results, beginning from 1866, since when the manufacture may be considered as being carried out regularly and steadily.

The Swedish converter was removed in the middle of the year 1866, and replaced by a second English or revolving converter of 80 cwt. capacity. The results obtained in this Swedish converter were quite or near as satisfactory as those obtained in the English vessel as regards the quantity and quality of the products and the consumption of fuel. But the amount and cost of tuyeres, bricks, and other lining materials required for the Swedish converter, were very high.

Table III, shows a very great consumption of cokes for heating the converters in the second half of the year 1866. The reason is that about this time the opinion prevailed that the heating of the converter to a high temperature, before the beginning of the charge, might be of great importance, and the experiment was made to see the effect. [It may, indeed, be seen from Table II, that during the same time the scrap produced by discharges from the vessel was considerably diminished.] In the beginning of the year 1868, the production had to be increased, and as the blast furnace was not able to furnish the required quantity of pig-iron, an additional number of charges were made with pig-iron remelted in a cupola furnace. Thus several charges could be blown in immediate succession, which circumstance lessened the consumption of heating fuel to a great extent. [The production of scrap was diminished at the same time.]

From 1866 to 1868, the steam for the Bessemer blast-engine was taken from the same boilers which furnished the steam to the blast-engines of the blast-furnaces.—These boilers being heated by the waste gases from the blast-furnaces, it was only necessary to burn some wood, in addition to the gases, to fully produce the quantity of steam required for the Bessemer engine.—Towards the end of 1868 separate boilers were put up, and were heated with bad and cheap fuel as lignite, cinders and small coal.

The increase in the consumption of lining materials, in 1869, is due to the use of a less good, but cheaper quartz. More fire-bricks were used in the last twelve months, because the cast-iron bottom plates below the moulds were replaced by frames lined with fire-brick. S.

GOVERNMENT AID TO SCIENCE.

From "The Engineer."

Two or three years ago several thousands of pounds per annum were placed by the late Government at the disposal of the Royal Society, to be expended in the establishment of meteorological observatories in different parts of the United Kingdom, in order to supply accurate daily weather reports to the Board of Trade. This step was not without its moral influence upon the scientific world, for at the British Association at Norwich last year, it was suddenly discovered that the scientific world generally was very badly off, and most decidedly in want of money aid from the Government. Lieutenant-Colonel Strange read a paper at Norwich on the subject. He acknowledged that Government aid would be certain to give rise to "jobbing" and jealousies, but urged that the good done would outweigh the evil. The opposite side of the question was then taken up by Professor Huxley, who said, with much reason, that the present free and easy way of pushing on scientific research was the best for the nation and best for philosophers. Nothing would so chill and deaden the energies of the scientific world as the transformation of any large portion of it into a Government department. The result of the conference at Norwich was the appointment of a committee of eminent philosophers to inquire whether adequate means exist for the vigorous prosecution of scientific research; and if not, what remedy should be provided.

So far everything went on swimmingly, but then a frost, a chilling frost, blighted the bright dreams of the philosophers. A new Chancellor of the Exchequer came into power, who has said "No!" many times and oft, to demands made by individuals and corporations for aid from the national coffers. He not only refused a modest demand for cash made by a Scotch scientific society, but expressed doubts whether the grant made for meteorological observations under the

Board of Trade ought to have been made.—The Government, he stated, ought to do nothing which the people are likely to do for themselves if left free to act. With the prospect looming in the future of facing a gentleman of this description, the Britith Association Committee, of course, could not very well come to the conclusion that application should be made for a Government grant, which every body a year ago thought would be the result of their deliberations.—But they have unanimously decided that scientific bodies want more funds; and what corporation of human beings does not? A direct onslaught on the nationl resources a being manifestly injudicious, they then recommended that application should be made for the appointment of a royal commission to inquire into the subject. Lieutenant-Colonel Strange read this report of the committee a few days ago at the Exeter meeting of the British Association, and he prefaced it with a doleful introduction of his own, read with the countenance of a mute at a funeral.

Many will doubtless think that a scientific journal is bound to support scientific men in all and every rush at the public purse.—Apart from the selfishness of such a line of action, and its neglect of the general interests of the nation, in this case it is no use doing so. Very recently an application of a very influential character was made to the Chancellor of the Exchequer to appoint a royal commission to inquire into the working of the Bank Charter act of 1844. This act is believed by the political economists to be the source of many commercial panics and of a vast amount of pauperism, while any banker can bear witness that it has indirectly been cause of the ruin and bankruptcy of many honestly managed banks.—Yet this application, of more importance than the one proposed to be made by the British Association, was refused on the ground of the expense of the commission, and because the action of the law upon the public is perfectly understood already by those educated in the science of political economy. Of course, once let the proposed commission on scientific needs be appointed, the result of the large amount of talk which would follow would not certainly be a recommendation of increased national expenditure. Instead of trying to obtain a few thousands of pounds annually in this way, with the certainty of failure, why do not the committee take steps to get a few tens of thousands of pounds annually from a more legitimate source? The subject of national education must soon come to the surface, and if the British Association then urged the necessity for general teaching of elementary science in schools, and the desirability of making grants to encourage this branch of education, all the members of the British Association would support the movement.—At present there is a division in the camp, and very many hold the views of Professor Huxley. If science were generally taught in schools we should soon have a population willing to subscribe largely to push on scientific research without aid from the Government. The Wesleyans have shown what enormous sums can be raised annually by private subscriptions, where large numbers of people join together in favor of any particular line of action. Those numbers may or may not be one in twenty of the total population, but is it hopeless to attempt to train up a similarly large number of people to have an interest in science? If the British Association and its president of next year were to make a dead set at the Government, insisting that the teaching of science in schools shall be a marked feature in all future educational legislation, they will succeed to a large extent, for they would carry national opinion with them. The present plan will fail, and even the intention mentioned by the President of section A, of getting up a discussion upon it before the settings of the British Association came to a close at Exeter, was abandoned.

THE SEWAGE OF TOWNS.

Abstract of a paper by Dr. BENJAMIN H. PAUL, read before the British Association.

This paper was the voluminous and valuable report of a committee on the Treatment and Utilization of Sewage. The report traced the history of sewage in England from the most primitive appliances, to the use of cess-pits, and lastly, of the present water carriage system. At the outset of the adoption of this system, it was contemplated to utilize it as manure, but was not enforced, and was now generally carried into the rivers and the sea so long as it did not create a great nuisance. The system now greatly polluted the rivers, and had become an evil of national importance. During the last thirteen years the subject had engaged the attention of three Royal Commissions, with a view to finding remedial measures,

The object of this committee was to supplement the efforts of the last sanitary commission, by obtaining special information of local influences of the experience of various towns. Town sewage, as now known, was a source of nuisances and inconvenience, and was undoubtedly injurious to health, and it became a very serious matter to determine what to do with it. The committee had obtained information of the sewage on the Continent and Austria. From this they gathered that both in large towns and country places there the old system of cess-pits was still in use, and water closets were rare even in large towns. In Berlin, with its population of more than 600,000 the still more primitive and objectionable night-stools were employed, 50,000 being in use every day. This was remarkable in a country so advanced in other respects as Prussia is. Hamburg was the only continental town in which water carriage system was carried out. In other places large portable reservoirs were used, and were periodically removed outside and there emptied. In some cases the householders pay for the removal, in others it is sold to cover the cost. In Antwerp the profits of the sale is two or three thousand pounds, and in Strasbourg the sale just covers the cost. The result of this foreign information was to show that the removal of sewage so as to prevent evil consequences, was at least as much an open question as in this country, and that there was an opinion that the collection of refuse materials was injurious to health, by exhalations, and by polluting rivers and wells, and that a remedy is required. The great question was to decide as to the best mode of dealing with the town refuse so that it might be satisfactory to health and would realize its greatest agricultural value as manure without its concurrent advantages. A series of questions had been sent to 338 towns in England, and answers had been received from 107 towns, of which 11 had no sewage at all, and in others the systems adopted were very defective; 48 towns had a complete water carriage system, and 15 applied the sewage to land, previously subjecting it to treatment. The results varied considerably, the local influences at work being very different. From some towns it was said that all obnoxious matters were removed from the sewage, and that it flowed off clear as water. It was questioned, however, by chemists, whether all deleterious matters were destroyed, and whether the clarification as seen by the eye was not all the advantage gained. This sewage manure was sold from 6d. to 2s. 6d. a ton, and one town mixing it with other substances, made a manure sold for 7s. 6d. a ton. Leicester sold 5,000 tons a year. The result of this utilization of sewage had been seen in the improved condition of the streams of rivers. Little objection had been urged against the use of sewage for irrigation of land, and where objections were made they were not supported by medical authorities. The cost of these various systems, and their influences on the sanitary state of the towns, were subjects for further inquiry. The ventilation of sewers was also an important question, for in them gases were given off and found to escape through the drains of the streets and of the houses. Such questions as the value of the sewage for agricultural purposes, and the best means of collecting and preparing the manure, required further consideration, and for this purpose it was suggested that the committee should be continued.

CAISSONS.—At Rochester, England, a bridge across the Medway was commenced in 1850. The piers were made of cast-iron caissons, 7 ft. in diameter, and driven a depth of 44 ft. into the bed of the river, through gravel, sand, rocks, and the debris of an old timber bridge, built, probably, by the Romans. At first the exhaustive process was used, but was soon found to be insufficient, and the atmospheric pressure process was tried. The caissons were then driven in an unexpectedly short space of time, and at one-third the estimated cost, through the obstacles above mentioned, and that to the great surprise of all engineers. However this was not the first experiment of the kind; it had been successfully applied several years previously in France, in sinking iron caissons through quicksands, in order to reach a coal mine at a depth of 82 ft. beneath the surface, the workmen having been exposed to a pressure of three atmospheres.

In several other works the vacuum process was first tried, but soon abandoned as insufficient. They were as follows: In the year 1851, the engineer of the Rochester bridge, W. Corbitt, built the piers of the Peterboro' bridge with cast-iron caissons 6 ft. square, placed in contact and afterwards filled with masonry. In the year 1853, Major Gwynne and L. Fleming built the

foundations of a bridge across the Pedee, North Carolina, with columns 6 ft. in diameter, driven a distance of 25 ft. through sand. Afterwards, they constructed the Santee bridge. In the year 1859, General Smith built the Savannah bridge. In 1860, the Third avenue bridge across the Harlem river was commenced. Brunel built a pier at Saltash with a caisson 37 ft. in diameter, sunk to a depth of 98 ft. below the water; it had the size and shape of the foundation of the entire pier, and was afterwards filled with masonry. All this was accomplished by means of atmospheric compression, and this system has, since the year 1850, met with more favor the better it has become known, until now it has become almost the universal method employed where currents are rapid and the river bed treacherous. The American experience is this, to wit: That in the Southern rivers, where cypress logs and other large objects are encountered, their removal by the exhaust system is utterly impossible, but, on the contrary, comparatively easy by means of the compressed air process which, therefore, is now exclusively used. Also, the most eminent engineers in England agree as to the utter insufficiency of the exhaust and the advantage of the plenum process. We will only mention Corbitt, Hawkshaw, Simpson, Brunel, Hemans, Brunlees, Page, Fox, Rawinson, Brereton, Fitzgibbon, Brassy, besides many continental engineers.

A caisson in which the air is driven down by means of pressure, notwithstanding it is worked on the principle of the diving-bell, is very distinct from it; because a diving-bell is a mere tool suspended from a vessel or from the shore, and used to lay foundations, etc., while the caisson forms a part of the foundation itself. The diving-bell is hoisted out, and when at the bottom is inaccessible, while in case of the caisson there is an uninterrupted communication with the outside. Our Harlem bridge contains also that improvement, which the builder, Wm. McAlpine, has termed "expansion of the base." The supporting power of the column is thereby greatly increased at a trifling cost. We will not confine ourselves to a description and illustration of English and Danish engineering works, overlooking the merits of our American engineers, whose achievements are equal in merit to those abroad. It is, however, unfortunate that they are too busy to give attention to descriptions for the benefit of the public. We will, in a following number, give a description of the process carried out in the construction of the Third avenue bridge. It is a very fine specimen of hydraulic engineering, though we cannot deny that it has two grave defects. It cost too much money, and was too long a time under way. In justice to the engineer we must, however, say that these were the faults of the political gentlemen then to be found over the way, in the City Hall, who had charge of the disbursement of the money required for its construction. — *Engineering and Mining Journal.*

PENETRATING INCLINED ARMOR.

From a paper read before the British Association by JOSEPH WHITWORTH, Esq., "On the Penetration of Armor Plates with long shells of large capacity, fired obliquely."

At the meeting of the British Association at Norwich, last year, I contributed a paper to this section on "The Proper Form of Projectiles for Penetrating through Water." This paper was illustrated by diagrams showing the effect produced on an iron plate immersed in a tank of water, by projectiles with flat, hemispherical and pointed heads. Copies of those diagrams are now before you. In that paper I claimed for the flat-pointed form of projectile, made of any metal, three points of superiority over the spiral-pointed projectiles adopted in the service: (1) its power of penetrating armor plates, even when striking at extreme angles; (2) its large internal capacity for bursting charges when constructed as a shell; (3) its capability of passing undeflected through water, and of penetrating iron armor below the water-line. This latter feature was, I think, satisfactory proved by the experiments described last year, and I desire to draw the attention of the section to the experiments I have made for illustrating the penetrative power of long projectiles with the flat front, fired at extreme angles against iron plates.

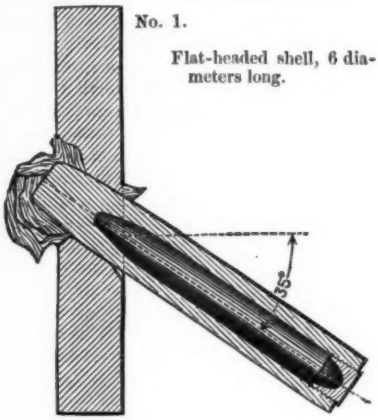
These experiments are illustrated by the projectiles actually fired, and the plates they penetrate, which are laid on the table, and also by the diagrams before you.

The gun from which the projectiles were fired is called a 3-pounder, though capable of firing much heavier projectiles. It weighs 315 lbs., and the maximum diameter of its bore is 1.85 in.

The charge of powder used, in all cases,

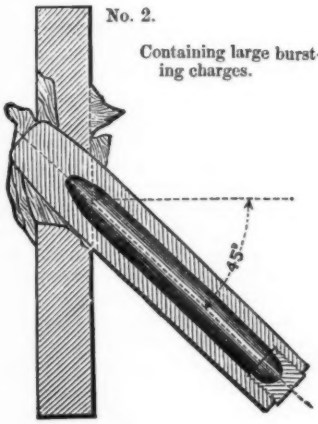
No. 1.

Flat-headed shell, 6 diameters long.

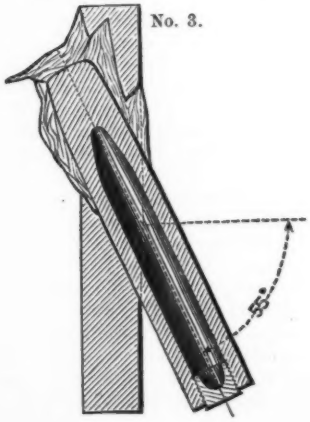


No. 2.

Containing large bursting charges.

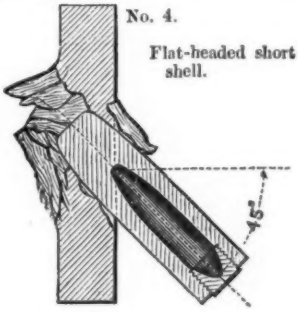


No. 3.



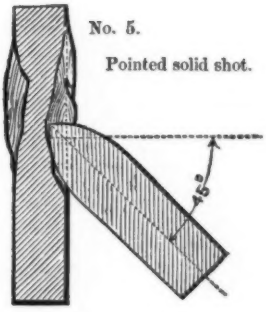
No. 4.

Flat-headed short shell.



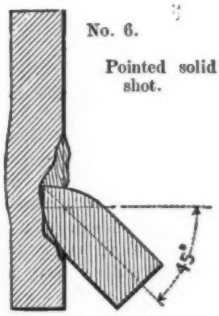
No. 5.

Pointed solid shot.



No. 6.

Pointed solid shot.



was 10 oz., and the weight of the 6-diameter projectiles is 6 lbs.

No. 1 is a portion of a plate 2 in. thick, penetrated by the 6-diameter flat-fronted projectile also; No. 1 at an angle of 35 deg. No. 2 is a similar piece of plate, 1.7 in. thick, completely traversed at an angle of 45 deg. by the flat-fronted projectile No. 2, which buried itself to a depth of 30 in. in a backing of iron borings. No. 3 is a piece of plate 1.75 in. thick, penetrated at an angle of 65 deg. by the flat-fronted projectile No. 3. No. 4 is a plate 1.7 in. thick, nearly penetrated, at an angle of 45 deg., by the $3\frac{1}{2}$-diameter flat-fronted projectile No. 4. No. 5 is a plate $1\frac{1}{2}$ in. thick, against which the ogival-pointed projectile No. 5 was fired at an angle of 45 deg.; the projectile failed to penetrate the plate, being defected in consequence of the pointed form of the head. The distortion of its shape shows the force with which it struck the plate, and proves the good quality of the material which could resist such a test. No. 6 is a plate also $1\frac{1}{2}$ in. thick, against which an ogival-pointed projectile, of the service proportions, viz: $2\frac{1}{1}$ diameters long, made of Pontypool white iron, has been fired; the projectile has scooped out a furrow 4 in. long and $\frac{7}{10}$ in. deep; it broke up into fragments, of which 48 were recovered.

The plates Nos. 1 and 3 were purposely thicker than the projectile could quite pass through, in order that the "work" of the projectiles might be as severe as possible; an examination of the projectiles themselves will show how well they have stood the severe strain to which they have been subjected. The data thus obtained fully establish, I think, the superiority I claimed for the flat-fronted projectiles made of my metal, and satisfactorily prove—(1) that the flat-fronted form is capable of piercing armor-plates at extreme angles; (2) that the quality of the material of the shells enables their length to be increased without any risk of their breaking up on impact, and materially augments their bursting charge as shells; (3) that this increase in length, while adding to the efficiency of the projectile as a shell, in no way diminishes, but, on the contrary, proportionally improves its penetrative power; (4) that the amount of rotation I have adopted in my system of rifling is sufficient to insure the long projectiles striking "end on," and, consequently, to accumulate the whole effect of the mass on the reduced area of the flat-front.

These experiments show, further, that the ogival-pointed projectile has but small power of penetration when striking at an angle, solely on account of the form of the head; a projectile of Whitworth's metal, with the like ogival-pointed head, as a service projectile, having resisted the shock of impact without breaking up, but being deflected in precisely the same manner as the pointed service projectile, which was shivered into fragments. The objections I made in my paper last year to the ogival-pointed projectile—(1) that its form of head causes it to glance off from plane or convex surfaces when hitting diagonally; and (2) that the brittleness of its material renders it liable to break up on impact—I have now proved to the section. The facts illustrated by these experiments are not of recent discovery. Ever since 1858 I have constantly been advocating the flat front. I have on the table a small plate $\frac{1}{2}$ in. thick, experimented upon, in 1862, with hardened steel bullets fired from my small bore rifle. No. 39 is the hole made by a flat-fronted bullet, which has penetrated the plate at an angle of 45 deg.; No. 40 is the indent of hemispherical-headed; and No. 41 of an ordinary round-nosed bullet, both fired at the same angle of 45 deg. These three rounds were fired in 1862.

Within the last few days I have had an ogival-pointed shaped bullet fired at the same plate at the same angle, in order to confirm the effect with that produced, on a larger scale, on the plate No. 6. It is interesting to observe how closely the results obtained with the small caliber of my rifle agree with those of the 3-pounder gun which form the subject of this paper. Those experiments recorded in the paper were made with a gun of small caliber, from considerations of economy and convenience; but I have always found that what I could do with the smaller calibers of my system, could be reproduced in the larger sizes; and from my past experience I feel warranted in asserting that the effect of penetration now exhibited could be repeated, on a proportionate scale, with my 9 in. guns at Shoeburyness, or with the 11 in. guns my firm are now engaged in constructing.

A glance at the formidable nature of the projectiles thrown by these guns, and a consideration of the effects they may be expected to produce, will show the importance attaching to the question of penetration of plates by long projectiles. The 9 in. guns

to which I have referred weigh fifteen tons each, and are capable of firing powder charges of 50 lbs. A 9 in. armor shell, 5 diameters long, weighs 535 lbs., and will contain a bursting charge of 25 lbs.

I have no hesitation in saying that these projectiles would pierce the side of a ship, plated with heavy armor, at a distance of 2,000 yards, and at some depth below the water-line. The 11 in. guns will weigh 27 tons, and will be capable of firing 90 lbs. powder charges. The 11 in. shells, 5 dial meters long, will weigh 965 lbs. and wil contain bursting charges of 45 lbs., and would pierce the side of the ship Hercules, plated with 9 in. armor, at a distance of 2,000 yards.

Were it not that the increased destructiveness of war must tend to shorten its duration, and diminish its frequency—thus saving human life—the invention of such projectiles could hardly be justified; but believing in the really pacific influences of the most powerful means of defense, these long projectiles I call the "anti-war" shell. The principle I have always insisted upon, and laid down for my own guidance in artillery experiments—when either a low trajectory or penetration is required—is, "that every gun should be in strength capable of withstanding the largest charge of powder that can be profitably consumed in its bore." I have drawn up the accompanying table of the sizes of the bores of my guns, with their proportionate powder charges, and the guns will all be fully equal to this duty, and I believe the greatest possible effect from the consumption of a given quantity of powder will be obtained. But the guns adopted in our naval service are not equal to such a test; nor, as I believe, are they so proportioned as to realize the best effect from the quantity of powder they consume.

Four guns of 12 in. bore have lately been put on board the Monarch. They weigh 25 tons each, and charges of 50 lbs. and 67 lbs. have been fired from them with projectiles of 600 lbs. weight. I have no doubt that these guns have been made with all possible care, and are as strong as their material and construction admits; but if the weight of these guns was in proportion to the capacity of their bore, and if the material were the best that our metallurgical skill could supply for such a purpose, they ought to fire 117 lbs. of powder, and projectiles of 1,250 lbs. weight. They would then be efficient weapons; but at present they are more formidable in name than in reality.

We are often flattered by being told that we have the best guns in the world. That may, or may not be the case. But I think that we should not rest contented while we are still so far from having attained as much as our present advancement in mechanical and metallurgical science has rendered possible for us.

Particulars of Ammunition for Whitworth Guns from 5.5 in. to 13 in. bore.

Caliber of bore.	Powder charge.	Common shells, cast iron, 3.5 diameters long.		Armor shells, Whitworth metal, 5 diameters long.	
		Bursting charge.	Weight of shell.	Bursting charge.	Weight of shell.
in.	lbs.	lbs.	lbs.	lbs.	lbs.
5.5	11.0	4.0	70	6.0	120
7.0	23.0	8.5	150	12.0	255
8.0	34.0	13.0	220	18.0	375
9.0	50.0	18.0	320	25.0	535
10.0	70.0	24.0	440	35.0	740
11.0	90.0	32.0	580	45.0	965
12.0	117.0	40.0	750	58.0	1,250
13.0	150.0	51.0	960	75.0	1,615

Mr. Whitworth's patent cartridge increases the range from 15 to 20 per cent. JOSEPH WHITWORTH & Co.
Manchester, 1869.

GAS FROM SEWAGE—A vague report of some experiments which have been made in India, and which, it is said, have resulted in the production of gas of high illuminating power from sewage, has set numbers of people speculating on the possibility of lighting London from the same source. If this could be accomplished no modern application of science could equal it in importance. It would at once remove a nuisance and convert an enormous waste into profit, and besides that would, in London alone, save the consumption of something like 1,000,000 tons of coal a year. While we are yet in ignorance of the mode of operating which has resulted in the success reported, we can only, with the knowledge we possess, speculate on what may be accomplished by different methods of treatment. Sewage in London, now well drained and well supplied with water, means animal excretia and household refuse largely diluted with water. What sewage means in India we do not know, but, according to Sir John Thwaites, it is solid excretia. Now, the only conceivable mode of obtaining gas from such a material as solid excrement, is by distilling it in a retort just in the same way as we do coal; and, as we know the chemical compo-

sition of the excrement, it is not difficult to guess what the result of the distillation would be. It would, in fact, be a disgustingly offensive mixture, consisting probably of marsh gas, carbonic oxide, carbonic acid, ammonia, and some other nitrogenized vapors, which would give to the whole an odor to which the smell of burnt feathers would be a perfume. No doubt most of what might be considered impurities in this mixture could be removed, and the two combustibles, marsh gas and carbonic oxide, left alone. But in this case the bulk of the gas would probably be reduced by at least one-half; and the remaining half would have no value for illuminating purposes, while it would be highly poisonous. We may say, however, that although we think it highly improbable that any olefiant gas or light-giving vapor would be produced in the process, it is quite possible that some might be present if any kind of fat were found with the excretia.

So far with the treatment of the solid matters. We may consider now how gas may be obtained from sewage diluted with a small quantity of water. Placed in close vessels and allowed to ferment, the result would be the slow production of large quantities of marsh gas, carbonic acid, ammonia, and a few other gases; but, again, the gas would give no light when burnt. If lime were added to the slush, marsh gas would be obtained more rapidly, and in larger quantities, and no carbonic acid would be mixed with it. If we take sewage such as we have in London, and allow it to ferment, we again procure marsh gas; but neither in this case nor with the slush do we procure gas possessing any illuminating power. We are quite willing to confess our ignorance of any feasible means of obtaining gas from sewage but those we have mentioned above. We shall probably be laughed at by those no better informed than ourselves. Meanwhile, we shall wait for an exact account of the experiments made in India, in the expectation of learning that something more than sewage has been employed. In dismissing the matter until we get the information, it may be worth while to notice what changes the manufacture of gas from sewage in London would necessitate. In the first case we put the use of solid excretia; it would involve the entire discontinuance of our present system of house drainage, and a return to cesspools, or some equivalent for them. If concentrated sewage be used, it means a double system of drainage for every house and the whole metropolis. Lastly, if ordinary sewage be used, it has been calculated, from the results of Dr. Letheby, who analyzed the gases produced in the fermentation, that to procure the gas required for one day and night in winter it would be necessary to store, in close vessels, twelve hundred millions of gallons, or more than a fortnight's sewage, which is nearly double the quantity that all the reservoirs of all the London water companies put together would contain.

Some other considerations present themselves, which we may dismiss very briefly. In the fermentation of sewage there is no doubt that various morbid poisons are developed. The poison of fever is generally believed to be derived from this very source, and, according to some, cholera is spread by the same means. A leak in a gas-pipe might, therefore, involve worse consequences to a household than result from untrapped trains. But on this matter it is needless to speculate. We say again we wait for information.—*Mechanics' Magazine.*

SURVEYING INSTRUMENTS.

By E. Sherman Gould, C. E.

NO. I.—THE SIXTY-SIX FEET CHAIN.

The ordinary chain used in surveying is very susceptible of, and very much exposed to, both extension and contraction.

1st. It expands and contracts by heat and cold. Its expansion between the freezing and boiling points is the $\frac{1}{1000}$th part of its length, or nearly $\frac{8}{10}$th of an inch. This source of error is of course neglected in ordinary operations.

2d. It stretches very much by being tightly drawn when in use, and is shortened by the links becoming bent. This must be guarded against by frequent comparisons with an accurate standard.

If the ground to be chained were perfectly level and smooth, a very high degree of accuracy could be obtained even with the ordinary chain. But in practice it is never so. The ground is always more or less rough and undulating, and these obstructions and deviations take up a portion of the chain, and make the measurements too long. The skill in chaining consists in knowing at a glance the amount of allowance to be made from the nature of the ground chained. I should recommend in all cases that the most experienced hand should go ahead.

This is contrary to rule, but I am convinced that it secures the best chaining. The follower has only to hold firm to the pin, and keep the leader in line, while the latter must estimate the amount of chain taken up by obstacles, etc., and make the necessary allowance.

On sloping ground (which should always be chained *down hill*, even if it is necessary to chain the slope backwards) the chain must still be held horizontal. In order to do this, it is necessary, sometimes, to chain in short lengths. The late Prof. Gillespie, in his admirable treatise on surveying, gives the following excellent method of handling the chain in such cases, in the following words: "To measure down a steep hill, stretch the whole chain in line. Hold the upper end fast on the ground. Raise up the 20 or 30 link mark, so that that portion of the chain is level. Drop a plumb line or pin. Then let the follower come forward and hold down that link on this spot, and the leader hold up another short portion as before." In this way the liability to error in adding up the short measurements is avoided.

When the whole chain is held up off the ground, the catenary curve that it forms will reduce the length at least an inch, if a good stretching pull be not exercised.

Under the guidance of an experienced leader, the measurement of 30 or 40 chains, if repeated, should not show a variation of more than a link, if the ground be at all favorable. This degree of accuracy should be insisted upon in important work. Greater accuracy cannot be obtained by the ordinary process.

NO. II.—THE COMPASS.

This instrument was formerly used for even the largest and most important surveys, but is now falling into almost entire disuse, except as in the form of a pocket instrument, and for some purposes which will shortly be mentioned. With it accuracy is unattainable, except through accident. The only reason why its imperfections are not more apparent is, that as the observations, unlike those taken by the transit, are independent of each other, their errors, by the doctrine of chances, are apt to neutralize each other to a certain extent. Were it otherwise, the results would be too grossly inaccurate to permit of the use of this instrument in any case.

The great vices of the compass as an instrument of precision are,

1st. Its susceptibility to local attraction.

2d. The diurnal variation of the magnetic meridian, which amounts sometimes to as much as a quarter degree between the morning and the afternoon of the same day.

3d. The impossibility of reading the instrument with exactness, owing (*a*) to the bluntness of the indicator, or needle; (*b*) to the fact that this indicator does not come in actual contact with the graduated limb; (*c*) to its unsteadiness; (*d*) to the insufficient minuteness of the graduation of the limb, it being necessary to estimate the number of minutes, less than 30, cut by the needle.

4th. The imperfect manner in which the instrument is usually adjusted, it being very rare that two compasses will agree in the bearing of the same line.

It must be borne in mind that I am now speaking of this instrument in reference to the higher operations of surveying, where a considerable degree of accuracy is required. For ordinary purposes, such as "running around" a small farm, particularly with a view to ascertain its acreage, the compass is undoubtedly the handiest instrument that can be employed in point of rapidity in the field, and the convenient shape in which the notes are taken for office computation. For all kinds of rough and preliminary work, too, where it is desired to obtain, with but little outlay of time, an approximate estimate of the "lay" and extent of a tract of land, and for reconnoitering, it stands without a rival, for by its aid a line can be run through the woods without felling any of the trees which intercept the view, and no back sight nor base are necessary, beyond those which the magnetic meridian itself furnishes. In a word, it admits of *superficial work* in association with a sufficient degree of accuracy for approximate purposes, which instruments, like the transit and theodolite, do not. It is, when it becomes necessary to lay out or survey with accuracy a large body of land; to range long lines and turn angles, that the compass proves itself a worthless auxiliary, and loses signally its great advantage of rapidity, for the work, where checking at first has to be tediously wrought into shape by successive approximations, the first locations being merely trial lines, from which the true ones must be deduced—a work of some difficulty, since lines run with the compass can never be quite straight.

In using the compass abundant time should be given for the needle to settle. It

should be borne in mind also, that the center of the compass, unlike the transit, is not necessarily directly over a certain point when a plumb line, suspended under the tripod head drops upon it, for the ball and socket of the compass is so high above the tripod head, that the centre of the instrument may be carried considerably to one side or another of the given point. In ordinary compass work, however, this is a matter of little consequence.

In running out lines with a certain bearing, the vernier may be advantageously used. Thus, to locate N. 12° 23′ E., set the vernier 23′ to the left, *i. e.*, as if for westerly variation, and run N. 12° E. by the needle.

In taking the bearing of a certain given line, the manipulation of the vernier is so tedious, that its use is generally abandoned by surveyors.

SUB-AQUATIC TUNNELS.

From "The Builder."

The anticipated success of a well-designed, though cheap and simple, tabular driftway under the bed of the Thames, has attracted a considerable share of public attention to the subject of subterranean, or subaquatic, communication. The idea of a tunnel, indeed, has been rendered so familiar to the inhabitants and to the visitors of London by the convenient service of the Metropolitan Railway, that persons who are devoid of the slightest idea of the difficulties with which the engineer has to contend, from the moment when he bids farewell to open daylight, come to speak of a tunnel as a very ordinary piece of work, and gravely discuss the feasibility of a structure of this nature, of the modest length of 30 miles, and at a level dipping some hundreds of feet beneath the bottom of the Straits of Dover.

Mr. Barlow's success, we trust, is now beyond doubt. Of the 1,320 feet demanded for his driftway, he has already safely constructed upwards of 1,000 feet; and the tube, advancing from a shaft on the northern bank of the Thames, has been pushed beyond low-water mark on the opposite shore. In his letter published a few days since, Mr. Barlow asserts that the very moderate estimate of 16,000 pounds for the entire work will not be exceeded. Should this prove to be actually the case, there can be little doubt of further demand on the skill of so economical an engineer. But the reason for which it occurs to us that it is most important that the public should not be misinformed as to the actual risks and difficulties against which the engineer of a tunnel has to provide, is as follows:

In all normal times of engineering activity, a marked and novel success, especially if it be a financial success, is apt to force a heavy aftercrop of more or less similar schemes. In these cases it too often follows that the modest anxiety and patient forethought which have led to the first triumph are altogether discarded by those who rush to follow in the same path. B has tunneled under the Thames; therefore C and D will fight for authority to tunnel under the Mersey, and E and F to tunnel under the Channel. Talk of the latter project as wild, and its supporters will point with triumph to the little *adit* by the Tower.

Tunneling, indeed, is not an invention of the present day, nor of the present century. That great engineering people, to the influence of whose institutions we owe so much of the very framework of modern civilization, wrought tunnels which endure to the present day. Two thousand two hundred and sixty-four years ago, the miners of Furius Camillus drove the famous *Emissarium* through a part of Mount Alba, and tapped the swelling waters of the lake of that name. Etruscan science, on this occasion, directed Roman energy. But the *tufa* of Italy, a material which behaves under the pick of the miner in a mode very similar to the English chalk, is bored and drilled with shafts, and *adits*, and lofty tunnels, in all directions. The gallery of Posilippo is familiar to every visitor of Naples. The curious system of galleries and caverns known by the name of the Grotto of the Sibyl, dates from a remote antiquity. Whether it were from an observance of hydraulic laws, from want of a trustworthy material for pipes, or from the conviction that the steady unchecked action caused by gravitation was best suited for the permanence and purity of a water-supply, we need not now pause to inquire. But certainly a knowledge of the engineering works of ancient Italy might have taught the English predecessors of Brunel more than they ever knew about tunneling.

The school for tunneling in England has been, of course, underground. In our mines, especially in our coal mines, the problem of constructing subterranean galleries has long been solved. In certain districts, such,

for instance, as that of the Peak, in Derbyshire, vast natural caverns open out in the living rock, glittering, when lighted up by the miner's torch, with sparkling stalactites, accessible, in places, only by narrow and low-roofed passages; and at times traversed, or occupied, by rivers, which long borrow from the light of day. In one Derbyshire cavern a river precipitates itself down an unfathomable abyss, and what becomes of the water is unknown.

But with all our practices as to mining, and all our acquaintance with natural subterranean galleries, the progress of the tunnel engineer was slow in this country, until the exigencies of the line selected by Stephenson for the London and Birmingham Railway led to the simultaneous construction of four wide and lofty tunnels, of dimensions before rarely attempted. It is true that the method of piercing the barrier that divided valley from valley had been pointed out, no less than the main directions of the best line of communication had been indicated, by Telford. The Grand Junction Canal was the pioneer and guide of the London and Birmingham Railway. But the canal tunnels were reduced to the minimum cross section. They admitted a canal boat, with the depth of water requisite to float it, and no more. In the earlier tunnels the boats were propelled—or, we might say, coaxed through—by the barbarous and painful expedient of the boatman's lying on his back and pressing his feet alternately against the roof of the tunnel.

In the case of the Thames and Medway Canal, a tunnel of larger dimensions was cut, through the chalk, at Rochester. A narrow tow-path was formed, in this instance, by the side of the water-way. In that tunnel, of some 2,000 yards long, the chalk in some places gave way, and lofty caverns diversified the usual elliptic section of the arch, which in only a few places, was protected by brickwork. When the Gravesend and Rochester Railway was laid through this tunnel, the Government Inspector, Lieut.-Gen. Sir C. Pasley, satisfied himself of the solidity of the chalk roof by the military expedient of *firing at it from a mortar*. He only used, however, wooden plugs.

The Kilsby tunnel was the scene of a most protracted, and for a long time a precarious, struggle of Robert Stephenson, with the great enemy of the tunnel miner—water.—So long and so continuous was the influx, and so far were the methods at first employed from being adequate to keep it under, that the abandonment of the work was at one time all but resolved upon. A quicksand full of water had been tapped by the tunnel, and till this was emptied, satisfactory progress was impossible. Notwithstanding the increased command of steam and of mechanical power which the last thirty-five years have placed at the command of the engineer, the experienced man will yet even now look grave at the prospect of tunneling through a hill that is likely to be wet, unless he can allow of the tapping of the springs, and the *bleeding* of the internal lake, by gravitation.

In this contest with the water at Kilsby, Robert Stephenson could indeed avail himself to some extent of the experience gained by Sir Mark Brunel and his assistants in their long struggle with the Thames. But the Thames Tunnel was unlike any other work. It was long considered, deservedly, and is still ranked by foreigners, as one of the wonders of the world. Skill, patience, energy, enough to have reared a monument of the loftiest dimensions, were buried in that horrible mine. Engineer after engineer was knocked up by labor, by damp, and by the ill effects of the deposit of the London sewage in the bed of the river. But the Thames Tunnel was a work *per se*,—a marine, or rather river, work, under most unfavorable circumstances, rather than a tunnel proper. The normal idea of the latter work is that of boring through the earth. The material may vary; props, and struts, and polling boards may be more or less constantly required; water may pour in, and necessitate constant pumping; but these are the accidents of the case (and very unpleasant accidents they are). They are not essential or constant obstacles to the boring through of a rocky or chalky barrier. Earth, or rock, is the natural bed of the ordinary tunnel. But Sir Mark drove through shifting mud. The square platform which grew together, brick by brick, as his many-partitioned shield was driven forward, was often within but a few feet of the bed of the Thames. It is even probable that, had the problem been affronted in the first instance, the engineer would rather have preferred to construct a double brick arch, working from one end, through nothing but water, than to deal with the ever-varying difficulties of mud, and silt, and clay, and wholesale inpour of the tide.

Indeed, Mr. Barlow claims for his well-

considered and simple shield, the merit that it would be so adjusted as to drive a tube ahead through water. It is far from being impossible that such a procedure should be carried out.

In the case, however, of the actual subway, the chief point to note is, that a wise provision has been exercised in fixing the level of the work so deep in the London clay that not a drop of water has entered the drift-way. That necessary for the purposes of the work has been send down the shaft. In fact, though no engineer would have felt justified in making the experiment, there is little doubt that the simple expedient of mining through the clay at the same level, "polling" the drift-way, and following the miners by a gang of bricklayers, who should have turned a brick and a half ring round the aperture, would have met with uninterrupted success. The one thing necessary in a case where, as in this instance, no faults occurred in the clay, would have been to keep up such a rapid rate of progress that the arch should always have been keyed in before the clay began to "creep." How certain, and how formidable, that creeping action is, Mr. Stephenson had ample proof in the Primrose-hill Tunnel. Under the influence of the successful experience of the Watford Tunnel, driven for the most part through solid chalk, the originally designed invert of the Primrose-hill Tunnel was countermanded. But the clay betook itself to fill up the hole drilled through its bowels; and the invert had to be put in, in very much of a scramble after all.

Men familiar with this description of work looked with a sort of amused surprise at the rose-colored statements which from time to time appear in the public journals as to a "Channel Tunnel." They do not say that such a work is impossible. They do not even care to form a distinct opinion on that head. But they are very well contented with the applicability of the proverb, "*Le jeu ne vaut pas la chandelle.*"

A better communication with France is no doubt both extremely desirable and perfectly feasible. Our present mode of transit, obnoxious as it is to the majority of ourselves, islanders as we are, and still more miserably and terrifically obnoxious (to judge from their countenances on deck) to most of our Continental neighbors, is hardly up to the requirements of the day. A safe, speedy, regular transit, free from doubt, from risk, and, above all, free from the fear of that horrible *mal de mer*, is what the English public have the right to expect of the profession of civil engineers, and what that profession will place at the command of the public, on the one sole necessary condition of being furnished with funds. These funds must be large, for the waves of the Channel are rough and tempestuous. But to speak of the sum requisite as one which would be adequate to the construction of a sub-marine tunnel, 30 miles long and 250 feet (some say yards) below the level of the *Manche*, is, to our mind, nothing better than grave trifling with an important practical subject.

It is curious to see how the non-professional imagination has not only run to flower, but to seed, about this question of crossing the Channel. The most remarkable feature in the case, moreover, is, that hardly any scheme is so absurd as not to find solemn-visaged propounders and open-mouthed admirers. It is evident that the material on which Law counted as the basis of his imaginary wealth is still to be found in rich abundance within our shores. It is only necessary to dig. *Les badauds ne passeront jamais.* Neither railway kings, with their royal mode of making things pleasant, nor colossal contractors, with their lines to develop traffic; nor financial companies, with their periodical crashes; nor Brighton directors, with their eight millions laid out so as to earn an annual loss, exclusive of the perished and annihilated interest; nor Chatham and Dover magnates, with their discounts of all per cent, have had more than a temporarily enlightening influence. We are told of scientific French evidence in favor of a grand Channel tunnel. By way of making a few preliminary inquiries, the Chancellor of the Exchequer is to be asked for the trifling sum of a couple of millions on account. The French Emperor, it is added, looks favorably on the scheme, and has given a conditional promise of as much more. All right; we rejoice to hear it.—We have only one point on which to insist. Let us get the French Emperor's money down *first*. Then it will be time enough to inquire about our own installment.

It is proposed, as caution is always desirable in engineering matters, that a drift-way should just be run under the Channel in the first instance, to prepare the way for the tunnel. The suggestion is at once economical, prudent and practical. Let us suppose a drift-way to be run, some five feet

or six feet high and wide. Is it to be timbered, or arched, or lined with iron? As the meeting from the two ends would be a thing forbidden by the calculus of probabilities, it will have to be worked from one extremity. As we get on—say beyond the twentieth mile, how will the miners be sent in to their daily work?—how supplied with air or materials?—how will the excavated chalk be sent back to land?

Galleries in chalk are infested, as miners are well aware, with choke-damp. What would be the quantity of choke-damp that would exude from 280,000 superficial yards of chalk surface (when the drift-way had advanced *only* twenty miles), and how would it be withdrawn?

Water infiltrates through chalk. A very small head of water will cause infiltration for a considerable distance. Where bands of flint occur they act like layers of sponge. All the wells in Strood, within a considerable distance of the Thames and Medway Canal, were rendered salt by infiltration through the chalk, when the brackish water of the Medway was admitted into the canal; and the company had to pay, and did pay, heavy damages in consequence. What would be the infiltration through the gray chalk due to the pressure of the water of the Channel? What would be the difference between the exudation from the 280,000 yards of surface at high tide and at low tide? How would the water, on its most modest estimate of its rate of infiltration (which by the by, would increase *de die in diem*), be removed? A few of these practical questions must be answered before we can undertake to speak, with any idea of serious investigation, as to the prospects of the Channel Tunnel.

But we are not limited to one scheme.—Their name is legion. One amateur proposes the formation of an embankment across the Channel, the top to be some 30 feet *below* low-water mark. Rails are to be laid on this embankment (which is kept down for the benefit of navigation), and long-legged carriages, of novel structure, are to run backwards and forwards over the submarine railway. We should like to let the laying of the permanent way to the projector.

Another gentleman proposes a floating tabular tunnel. It is to be moored at certain distances by chains. The process of anchoring and straining the chains at the bottom of the Channel would be highly interesting. Supposing—not to make two bites of a cherry—the tube complete, moored and at work. What a grand idea to think that the whole service of the Continent, and the lives of all who happened to be at any time in a structure that recalls the legend of Mahomed's coffin, would be at the mercy of a beggarly gun-boat, or a mischievous torpedo!

In fact, we warn our friends, when called on for subscriptions for a Channel bridge, or tunnel, or hybrid between the two, to button up their pockets, and wait. The limits of the service of the engineer are, no doubt, rather financial than physical. The limits of speculative imagination appear to be equally removed from the barriers of prudence and from those of experience.

Returning for a moment to the Tower subway, we would mention that the work has been carried forward by the advance of a tabular wrought-iron shield, about 8 ft. in diameter, which is so constructed as to form a close bulkhead in case of need. As this shield is pushed forward by screws, the excavators opening out the ground for a few feet in advance, the permanent tube of the subway is fitted into place behind it, being cast in 18-inch lengths, each consisting of four segments; three of which are of equal size, and the fourth is a mere key-plate, 14 in. or 15 in. wide. Length by length these narrow plates are bolted on the face of the tube, being protected, until firmly fixed, by the shield. The introduction of the narrow wedge-piece has proved a great facility in fitting together the segments of the tube.

The internal diameter of the completed tube is 7 feet. A narrow railway will be laid throughout, and the passengers, being lowered down the shaft by a vertical hoist, will be carried through the subway in an omnibus specially constructed for the purpose, propelled partly by gravity and partly by haulage by a stationary engine. A curious feature in the actual construction of the tunnel is the filling up of the small space, excavated outside of the tube, with blue lias grout. A hole is left in each plate, and through this the grout is driven by a large syringe until the aperture is completely full. The mixture dries so rapidly that it is unnecessary to plug up the holes on the removal of the nozzle of the squirt. How far that irresistible oxidation of the iron (by absorption from the grout), of which we have recently seen such a striking instance in the tomb of King Henry VII, will proceed, remains to be seen. It seems almost a penny-wise-and-pound-foolish proceeding not to

have enameled, galvanized, or otherwise protected, the inaccessible exterior of the tube from a very formidable danger which there is no means of detecting until it is too late. Mechanically considered, the injection of the grout is admirable. Chemically regarded, we fear that the same cannot be said.

We avail ourselves of the opportunity to call the attention of all managers of tunnels, mines, and similar works, to the immense facility afforded to the work by the use of the electric telegraph. A constant and instantaneous communication is kept up by the wires between the engine-driver and the face of the work. Lowering and raising of materials, and admission of air by the fan-blast, are thus precisely directed by the foreman on the work itself. The sense of confidence that would be inspired in any case of danger by the possession of this mode of communication would be beyond all price.

THE MANUFACTURE OF RAILS.

From a paper by Mr. E. Williams, before the Iron and Steel Institute, and the discussion following.

In this paper Mr. Williams stated that he proposed to give as concisely as he could the opinions he entertained as to rails, and to consider, from the stand-point of a rail-maker, the several kinds of rails in use, the merits and demerits of each, together with the processes of manufacture generally used. The paper said: The rails of to-day are of two distinct kinds—those made from ingots and those built up; and it must be admitted that—questions of cost and possible supply not considered—ingot-made rails are best. We are in the habit of describing the two kinds as steel rails and iron rails—a description obviously incorrect—because the Bessemer rails now making have a percentage of carbon much lower than that of steel proper as we used to know it. Besides, it is, so far as I know, impossible to define when iron ends and steel begins. It will then be as well to call the two divisions ingot rails and piled rails.

For many years makers of iron by the old processes have desired and endeavored to produce ingots or blooms, each from a single puddled-ball, that would roll into rails. This, if it could be done, would, I have no doubt, make rails equal to any ever made; but the difficulties seem insuperable. Puddled-balls of sufficient size have been, and may be obtained; but it appears impossible to produce moderate compactness of the iron without more work upon it than is possible in one operation. I have come to the conclusion, though most unwillingly, that we shall not succeed in producing by puddling, workable, unwelded, solid blooms and, so far as our present knowledge extends, ingots cheap enough to make rails on a considerable scale are only to be obtained by the Bessemer process. Whether or not the Siemens-Martin process can compete, in point of cheapness of production, with the Bessemer process, is as yet unproved, and the question need not arise here. It is sufficient now to know that both can, without doubt, produce ingots that roll into rails without much difficulty, and that such rails, being free from the possibility of lamination, must be more enduring than built-up or piled rails, however carefully made. It is not unlikely that further experience may determine the precise constitution ingots should have to produce the most enduring rails, but at present this is matter of opinion only. The freedom from welds and layers is an enormous advantage, and the use of ingot rails will, I feel sure, go on increasing, though the rate at which they will push piled rails out of existence must, of course, depend on the relative costs.

If the phosphorus difficulty could be got over, and the cheap pigs of the Cleveland district were available for the Bessemer process, there would be so great a reduction of cost that ingot rails would be almost as cheap as piled ones, and the latter must at once give way; but there is not at present any good ground for expecting that such a change is near, and I see no reason to suppose that for some time to come ingot rails will become anything like universally used, because of their price. The removal, in February next, of the bulk of the present Bessemer royalty-charge, will, no doubt, reduce the selling prices of ingot rails; but I am mistaken if, after all, they can be produced so as to be sold within 40s. or 50s. per ton of the average selling price of good piled rails, the life of which, in the ordinary portions of a heavily-worked railway, would be about fifteen years. For the very severely-worked places ingot rails, at almost any moderate extra price, are, of course, best.

Strenuous efforts have been made by nearly all the great iron makers everywhere to produce steel topped rails, which, it was hoped, would be much more lasting than the usual piled iron rails, and less costly than

ingot rails. Puddled steel seemed to offer a cheap and good material for this, and after some difficulty to begin with, it was produced of uniform quality. It is, no doubt, a material capable of resisting well the wear and tear of railway stock, but it could scarcely be welded at all, and as it could not be obtained in solid blooms of the rail size, the system failed and has been abandoned, in this country at least, entirely. That Bessemer steel slabs can by great care and skill be so fastened to iron as to make rails that will wear well is proved by the instances of the rails supplied to the Edinburgh and Glasgow Railway and to the Swedish Government. Probably there have been some other instances also, but I do not expect to find such rails coming into general use, because of the difficulty of welding on the steel plate, which is not much, if at all, less than that of the puddled steel before spoken of. It need not be told to this meeting that steel, however mild, will only stand a comparatively low heat, while iron, to weld at all, must have a high one. Giving the steel top a mechanical grip is, no doubt, to make the best job possible, but the channel steel slab has the disadvantage that the horns prevent the escape sideways of the superfluous cinder, which at best interposes too much between the layers to be welded together. This could not fail to produce faulty welding, which the traffic of an English railway, such as the North-Eastern, would certainly bring to light despite the mechanical fastening.

So far as I can see, then, the only choice as to rails lies between those made from ingots and piled ones, and in the uncertainty as to the Siemens-Martin process it may be assumed that the Bessemer process will supply the former. I do not desire to convey any doubt or even opinion as to the practical value of the Siemens-Martin process; but it is not yet, in England at least, in operation for rail making on more than an experimental scale, and it is therefore uncertain what proportion of the rail ingots of the future it will supply. The present price of ingot rails is about £10 per ton for usual flange sections, and it is, I believe, the fact that this is not remunerative. After February next makers will save most of the royalty for patent right, and it may be assumed that rails will go down say to £9 per ton. While ingot rails are at anything like this price, good piled rails, the average selling price of which is not £6 10s. per ton, and which, under moderate traffic would live on the average 15 years or more, will, I believe, hold their ground and be in demand. I wish to make it clear that my remarks apply only to good iron rails; the very lowest kind is only bought by those who give themselves no concern as to quality, and first cost will in such cases be the only considerations.

It is not unfrequently asserted that, as a rule, the rails (of course all piled rails) of twenty years or so ago were of a more enduring kind than those supplied now, and I think there is some truth in the accusation. It must not, however, be forgotten that the duty imposed on rails now is very much in excess of that they had to bear in the early days of railways; and that, therefore, mere length of life is not a correct standard by which to measure their quality. As the weight upon the rail increased, engineers and manufacturers simultaneously adopted the use of more fibrous iron as a preventive. Still every now and then a rail would break despite the extra endeavor to prevent it, and notwithstanding the heavy and heavier tests which rails were required to stand. This has gone on for many years until not a few of the specifications framed by engineers, certainly with the view of ensuring excellence of quality, bring about the reverse, because to meet them, rails are made of fibrous, and therefore difficult welding iron, at an increased cost, and less serviceable than those made after a simpler system. Even, after all the additional cost and the diminished value of the tougher rails, there is an occasional breakage (as there is also now and then a breakage of ingot rails), and I am of opinion that it will be so, despite all possible care, and irrespective of price.

We all know that a percentage of piles or ingots heated are, even by the best workmen, so over-heated, at some stage or other, that they fall into pieces, or become torn in the rolls; there are also, no doubt, some which are heated a shade short of this point, and just hold together, but are almost as brittle as porcelain when finished. This occurs while the great bulk of the rails are abundantly strong, and I do not see how any system of testing can detect the unfortunate instances. They cannot under any tolerable supervision be more than a small proportion—under good watching very small—but I am afraid they will always be a proportion, as there is in the case of crucible steel tyres, which cost eight or ten times

as much as rails, and which have all possible care and skill devoted to them. Supposing the all but broken rails to be 1 in 100,000, it will be evident that there is small chance of that one being selected for testing, and if it were chosen, it would be found so exceptional that nothing more serious would follow than the testing of a few more rails to prove that it was exceptional.

I do not at all advocate the discontinuance of the system of testing rails—no prudent maker would abolish it even though it were not insisted on, but it is, I am sure, the fact that the excessively heavy falling weights, prescribed frequently, do necessitate the use of iron for rails that welds with difficulty, and, therefore, does not make the best rail for wear. To meet the severe falling tests it is absolutely necessary to use fibrous iron, and not to heat too much—in fact, to make the piles of iron that, do what you will, is very difficult to weld, and then not to give them the amount of heat necessary to make as good a weld as might be. On this subject I have thought and experimented much, during a somewhat long experience, and I am satisfied that a fibrous nature and weldability do not go together, and that only well-puddled, crystalline iron welds easily, and, therefore, with moderate certainty. Given any kind of wrought iron, it welds more easily in its first stage, that of puddled bar, than at any future one; and the effect of roughing it down, that is, of extra piling and rolling, is always to diminish the weldability of the resulting rail piles. Those who make cable bolts, best boiler plates, and other similar iron, know how certainly they are spoiled if they are worked hot—in other words, if they are welding hot. Cable bolts for a chain are not the worse, but the tougher and softer, because the layers of which they are composed are only firmly struck together, and not welded; but in rails welding is the very life itself. As often as opportunity offered, I have carefully examined rails that had borne an unusual amount of work before becoming so worn as to be replaced, and in, I think, every instance they were what we now would call very brittle rails, and had a rough crystalline fracture when broken under a falling weight.

It is, I think, undesirable to use rail piles of great cross sectional area, which are less likely to be heated equally to the centre than were the small piles of a century ago. Rails at present are heavier and longer than formerly, and it would not, I presume, do to go back to piles 6 in. square, or thereabouts; it would, however, I think, be well not to exceed 8 in. by 8 in., which, with blooming and double-heating, might be well welded. The two great rail-producing districts of this country are Wales and the North of England, and each has a system of working different from the other.

These systems have been explained in detail, and with the aid of diagrams, Mr. Williams went on to say "that the Welsh system has the merit of more work on the iron, that is, greater consolidation, than is obtained by the north of England system. This is a doubtful advantage, if it is really, as I believe, that the iron for rails is, as a rule, too much worked, while it has the demerit of having many through welds in the heads of the rails. The north of England system produces hard crystalline heads, with the fewest possible welds, and when the iron of this district is not too much worked, and thus made fibrous, it is of the most weldable kind, though somewhat brittle. Such iron, it seems to me, is likely to produce enduring rails, and I firmly believe that with proper attention, piled rails can, and will, for a long time yet, be made from it, so enduring as to compete successfully with good ingot rails, produced by the Bessemer process." Mr. Williams concluded: "My desire has been to lay before those who make, and those who use rails, the conclusions my experience has produced, as to the causes of the unsatisfactory wearing power of piled rails, and to show how, in my opinion the evil may be abated. The subject is very important to all, and to no class of men more than to those who, like myself, make piled rails. These are now in competition with ingot rails of the Bessemer process, and cannot, I think, possibly continue in demand, unless the greatest care be given to the manufacture, both as regards the iron used and the welding. Welding, I hold to be the one thing needful, and we should never lose sight of it. As I have before said, the chance of obtaining thorough welding would be much increased by not insisting on more toughness and fibre than is absolutely necessary to guard against so much brittleness as would bring about breakages o the rails in work."

Mr. J. T. Smith (Barrow-in-Furness thought there was a point on which Mr. Williams was misinformed, and that was that in a few months (in February) when the Bessemer royalty would be reduced,

rails of that character could be had at £9 per ton. So far as he had been able to ascertain, rails had been at very nearly that price for a considerable time, and the majority of the steel rail masters were looking forward to the time when the royalty would be reduced, that they might be able to recoup themselves for the expenditure they had had on their works.

Mr. Walter Williams (Tipton) briefly described the manner in which rails were manufactured on the Continent, especially in Russia. He had seen from a 12 in. pile rail finished at one heat, the head crystalline and the flange fibrous. If they were able with their common puddled iron to make rails that stood the test that our iron stood, there must be really something in the first process. The rails were rolled out at the rate of one a minute—100 revolutions were attained by the rolls—with perfect crystalline top and fibrous bottom. The welding must be perfect, or the defect would evince itself in the crystalline top. The iron was similar in quality and character, and if they were able to do it there, it must be possible to do it here.

Mr. Hopkins (Middlesbrough), as one practically connected with the manufacture of rails, presumed the author, in condemning the system of excessive testing, applied his remarks especially to double-headed rails. If so, he entirely agreed with him. Practically, a lighter test was sufficient to secure a thoroughly good, general wearing rail, and a rail that would stand the traffic of any railway. As regarded the rail with wearing head and flange foot, to make a bearing on the sleeper, a much heavier test could be applied than in the case of double-headed rails; for in the former the fibres were at the foot of the flange of the rail, a crystalline head being still preserved.

Sir William Armstrong need hardly say that, in the manufacture of guns upon the coil system, a perfect welding was of just as much importance as it was in the manufacture of rails; and great attention had been given both at Elswick and at Woolwich, to the devising of a test which should indicate with some degree of certainty the fitness of the iron for the purpose of making a perfect weld. The conclusion arrived at eventually was this (and it was arrived at both in their practice at Elswick and at Woolwich), that in proportion as the iron had a steely character, so in proportion it was unfavorable for welding. The indication of its steely character was obtained in this way—they took a specimen of the iron, heated it to a certain point, and then plunged it into water; if they then found its tensible strength was increased beyond a certain limit, it was rejected as unfavorable for welding. That iron welded most perfectly which underwent no increase of strength in the process of hardening. Almost all iron did receive an accession of strength similar to that observed in steel by the process of plunging when hot into cold water, though to a less degree. He had a little difficulty in reconciling what he had just stated with what Mr. Williams had said in reference to the constant reworking of the iron, unless it did assume something of a steely character, which he had some difficulty in understanding. Then there was another point on which he might speak, though with more diffidence, and that was in regard to the mode of testing rails. The test which was ordinarily practiced of selecting a particular rail—allowing a heavy weight to fall upon it—might be very well for indicating the general character of the material, but it was not at all a proper method of welding out the rails which were defective in manufacture. He did not see why there should be any difficulty in exposing a rail to a moderate test of that kind. It would not be difficult to devise some apparatus by which that should be done without any manual labor at all. If the rails were laid on a moving machine and struck with a certain force which would not endanger a good rail, but which would as certainly break all rails which were inherently bad, the end would be answered.

Mr. I. L. Bell felt that the quality of rails generally had suffered materially from the wish on the part of the buyer to obtain the rail at far below the cost at which it could be produced, and secondly, harm had been inflicted on the manufacturer by the demand for a species of test utterly unnecessary and excessive. They had on the North-Eastern Railway a great number of rails which had worn uniformly down until from absolute wear they had become unserviceable. It became a most interesting question to him to know what was the character of that iron which had been better able to stand the wear and tear of the railway than iron which appeared to be of a much better quality. He subjected it to an analysis, conducted by Mr. Marreco, a very competent person, who discovered not in one instance only, but in many, that the rails were dis-

tinguished by the excessive amount of phosphorus they contained; and, in point of fact, was precisely due to that quality, in which, probably, Cleveland stood preminent.

Mr. T. W. Plum (Old Park Ironworks, Shropshire), thought it worth investigation whether a homogeneous rail from the solid bloom might not be made very nearly approaching in durability and quality to some of the steel rails. The days of steel rails were coming very fast upon them, and it might be worth while for the iron rail makers to turn their attention to the subject. As regarded welding he might say that he had had some little experience in working iron for guns at Woolwich, and some time after that he had to start a tyre mill on the coil principle, similar to that adopted in the construction of guns, except that the bars for the welding were flat instead of square as used for guns. He encountered some difficulty in getting the coils to weld properly, and after some little experience he had them made with convex sides; and so superior was the result obtained by the use of convex bars that, having on some occasions had Swedish iron which was difficult to weld made into tyres, the result was perfectly satisfactory. It was desirable to consider whether rails could not be made from solid blooms, instead of piles as hitherto.

SCIENTIFIC *vs.* PRACTICAL SCHOOLS.

From the "New York Times."

Although the subject of education—classical and scientific, practical and polite, popular and technical—has never been more warmly and widely discussed that at present, there are notable differences of opinion and practice regarding the educational requirements of classes, and the most effective methods of instruction. While we rejoice at the maintenance of the classical department in the great free school of this city; while we cannot too highly appreciate, in this greedy and utilitarian age, the polite and scholarly culture of our older universities, it must be admitted that the dissemination of *practical science* is the great problem of the day.

Education is popularly divided into "classical," that is to say, scholastic and polite, and "scientific," by which is meant practical, useful, and adapted to the daily and modern wants of the nineteenth century workers: but it should appear that this classification is incomplete. If we mean by "classic," pure, chaste, refined, then some of the natural sciences, and above all, the higher mathematics, exhaust that definition, though usually classed as scientific; and certainly nothing could be less practical or more imaginative, not to say poetic, than for instance, the mechanical engineering taught in many of our scientific schools.

In as far as education is a disciplinary process for fitting the mind to work, there must be little to choose between Greek and mathematical roots; but in as far as it pretends to unfold the particular and practical arts and sciences by which graduates can earn fame and bread, it must be admitted that the curriculum of our practical schools, especially in mechanical science, is singularly defective. In his address before the mechanical science section of the British Association, Mr. Siemens, the President, gave authoritative expression to this idea by saying that the information conveyed to students by professors lacking themselves practical experience, "tends to engender a dogmatical conceit, which is likely to stand in the way of originality in the adaptation of new means to new ends; on this account I should prefer to see a sound 'fundamental' education, with a sketch only of the technical arts, followed up by professional training, such as can be only obtained in the workshop, the office or the field." Those who are familiar with the real requirements of practical scholarship, will recognize this to be a peculiarly timely and wholesome statement of the case—but it is a pretty severe commentary on our technical schools.

We wish to be particularly understood as not applying these strictures to all branches of scientific culture. The pure mathematics, as made signally practical in navigation and in certain features of construction, are wholly theoretical, and the authority and method of their teaching in our better schools are unexceptionable. So it is with chemistry, in most of its ramifications, although practical metallurgists could wish for more definite instruction, and less general speculation.

The successful teaching of mechanical engineering, however, must be founded upon an intimate knowledge of the practice. In some branches of technical instruction, lectures are well enough illustrated and improved by means of visiting, from time to time, the establishments where the science is reduced to an art. But neither the theorist, nor the careful observer, nor even the

amateur mechanic, can teach young men to run a machine-shop, or to build, or even design steam engines, rolling mills and general machinery, for the following reasons:

First—Although the strength of materials, as subjected to different kinds of statical strains, is a matter of text-book information, machinery designed by these lights *alone* always fails. There must be, above and beyond all tables and formulæ, a certain mechanical judgment as to the proportions and relations of parts. A bearing that will carry a certain load in a stationary engine, housed, clean and never overstrained, may be very inadequate to the same nominal service in a rolling mill or in a locomotive, where frictions and strains may be excessive. The circumstances of over stress, exposure, attendance, convenience of repairs, and other accidental conditions may entirely change the designs of machines subjected to nominally the same service. Experience in construction has also established certain principles of departure from general laws of strength. The reduction of friction, and even more notably, the steadiness and balance of parts, requires in many positions an excessive amount of material. On the other hand, especially in the case of the machinery of transportation, experience has shown the importance of reducing weight at the cost of stronger materials and shapes.

Secondly—The principles of economy, not only of material, but of the work put upon it in construction and in maintenance, must be perfectly familiar to the successful mechanical engineer. No matter how well a machine will perform its functions, if the shape of the parts is such that they cannot be cast, or wrought, or finished by the tools at hand, with the least amount of handling or work, or if the parts are so put together that they cannot be easily taken to pieces for repairs, the machine is to that extent defective.

It is, therefore, evident that mechanical engineering cannot be successfully taught by professors whose knowledge of machine shops and foundries has been derived from walking through them with their classes. Nor does it follow, on the other hand, that one must serve an apprenticeship at the vise and the lathe to acquire the principles of mechanical construction. There is, indeed, little or no strictly educational literature in these branches, but of course there will be, and it will be adequate and suitable, as soon as the men, who alone can produce it, are called upon for lectures and text-books. Until then—until instructors are not only scholars, but the personal designers and builders of successful machinery, students in mechanical engineering had better take Mr. Siemens' advice, and simply master the elementary principles of physics, dynamics and mathematics, and then go to work in drawing rooms, foundries and machine shops, even under the embarrassment of but partially utilizing the many hours at the vise and the lathe, which could be more profitably and economically devoted, if one had more practical teachers in our "practical" schools. Let no one be deceived by names, or by proposed courses of study. The steam engine, for instance, is the subject of lectures in some of our colleges, that brings the invention nearly down to the time of Watt. The training of professors in mechanics and engineering that has been commercially productive, as a business, is the test by which the usefulness of their schools may be chiefly determined.

When young men who want to excel in this branch of industry, hear that experts like Fairbairn, Corliss, Whitworth, Sellers, Worthington, Armstrong, Ramsbottom, Allen, and many other of whom these are types, are going to lecture on steam and general machinery, let them go and listen, at any cost. It may be difficult, but it should not be impossible to secure this kind of talent and training for our chairs of mechanical engineering. Few public questions are of more importance than the proper instruction, in this distinctively engineering age, of the young men who are crowding into this profession. The managers of our educational institutions are charged with a grave responsibility, and the various men of means who are contemplating the endowment of schools, can hardly extend their liberality in a more useful and timely direction.

CABLE TOWING on the river Meuse, which we have heretofore described, appears to be an entire success. All the embarrassments of swift current, varying depth, locks and sharp curves, appear to have been overcome. Inasmuch as it would not interfere with horse-towing, nor require any change in the works, and since a State expenditure of only some $500 per mile for cable would be required, we hope that, say, 50 miles will be at once laid on the Erie canal.

THE "DUTY" OF INJECTORS.

From "Engineering."

The question as to the relative economy of injectors and pumps as boiler-feeders has been frequently discussed, but, as a rule, the arguments on both sides have been founded upon data greatly wanting in scientific accuracy. As far as we are aware, scarcely any reliable experiments have been conducted in this country to ascertain the amount of steam actually used by an injector in performing a given amount of work; and we are, therefore, glad to see that, in an appendix to a recent number of his work on "Steam, Air, and Gas Engines," Mr. John Bourne gives the details of a series of experiments lately carried out by him to obtain some definite information on this point. Mr. Bourne's experiments were made with a No. 6 Giffard's injector, which was made to draw water from a tank, and deliver it, past a loaded valve, into another tank standing at a lower level. The valve, which was of the piston kind, was loaded by a spring-balance, so that the pressure upon it could be adjusted, and both tanks were fitted with gauges. Steam was supplied to the injector from a small vertical boiler, the chimney of which was furnished with a damper, so that an uniform pressure of steam could be maintained, while the boiler was also fitted with a graduated gauge, so that the quantity of water evaporated during each experiment could be noted. The temperature of the water supplied to, and delivered by, the injector was also ascertained at numerous frequent intervals.

Mr. Bourne, however, although he gives the full details of his experiments—which are altogether 67 in number—does not show how the heat abstracted from the boiler is utilized, but he merely remarks that: "As, then, these experiments show the quantity of water evaporated from the boiler, under a determinate pressure, and also the quantity of water lifted against a determinate pressure or head, by the volume of steam answering to the quantity of water evaporated, the duty of the instrument, in any experiment, can easily be deduced, *and it will be found to be very low.*" As to this latter deduction, which we have printed in italics, we either agree or disagree with Mr. Bourne, according to the meaning assigned to the term "duty." If the "duty" of an injector is measured merely by the quantity of water delivered by it against a given pressure by the consumption of a given quantity of steam, then undoubtedly the "duty" of the instrument is, as Mr. Bourne states, extremely low. But an injector not only serves the purpose of a pump, but also heats the water delivered by it; and when employed as a boiler-feeder, the only heat which can be fairly said to be absorbed in working the instrument is the difference between that abstracted from the steam passed through it and that imparted to the feed-water. Measured according to this standard, the "duty" of an injector will be found to be very high; indeed, so high that it would require some experiments of a far more precise character than any yet conducted with the instrument to determine the absolute loss. It is, we think, far from being generally recognized how small a proportion of the steam passed through an injector is actually utilized in forcing the water into the boiler; and it may be interesting if we analyze one of Mr. Bourne's experiments, and show the information which they afford on this point.

As our example, we shall take an experiment in which the pressure against which the water was delivered was the same as that at which the steam was supplied, the circumstances being thus those under which the majority of injectors in use work. The details of the experiment are as follows:

Duration of experiment	12 minutes.
Pressure in boiler.....	30 lbs. per sq. in.
" against which water was delivered	30 " "
Quantity of water evaporated..	5 gallons.
" " drawn from supply tank	90 gallons.
Quantity of water delivered as measured in receiving tank..	100 gallons.
Initial temperature of water ..	52° Fahr.
Mean final temperature of water	117° Fahr.

As the water in the boiler would have a temperature due to that of steam at 30 lbs. pressure, namely, 274.4°; and as water at this temperature weighs 58.17 lbs. per cubic foot, the 5 gallons evaporated would weigh $5 \times .16 \times 58.17 = 46.536$, or, say, 46.5 lbs. Again, the total heat of steam at 30 lbs. pressure is 1,197.6°, and as during the experiment we are considering the steam was condensed into water at a temperature of 117°, each pound of it lost 1,197.6—117 = 1,080.6, or, say, 1,081 units of heat. The total heat abstracted from the steam used during the experiment was thus $1,081 \times 46.5 = 50,266.5$ units.

On the other hand, the weight of water

at a temperature of 52°, being 62.377 lbs. per cubic foot. The 90 gallons supplied to the injector would weigh 898 lbs., which, added to the 46.5 lbs. resulting from the condensation of the steam, gives 944.5 lbs. as the weight of the water delivered. Mr. Bourne, however, gives the quantity delivered as 100 gallons at a temperature of 117°, and taking the weight of water at that temperature as 61.7 lbs. per cubic foot, this would correspond to a weight of 987 lbs., or 42½ lbs. more than as determined above. This difference is, however, not greater than might be naturally expected in experiments of this kind, in which, unless many minute precautions are taken, there is a considerable liability to small errors arising from the expansion or contraction of the measuring tanks, etc. If, in the present instance, we take the larger quantity, or 100 gallons, as that actually delivered by the injector, we shall have 16 c. ft. of water delivered against a pressure of 30 lbs. per sq. in., or 4,320 lbs. per sq. ft., this corresponding to the performance of $4,320 \times 16 = 69,120$ foot-pounds of work. Dividing this number by 772 (Joule's equivalent), we get $\frac{69,120}{772} = 89.5$ as the number of units of heat actually required to perform this work. But it has been shown that the steam abstracted from the boiler parted with 50,266.5 units of heat, and there therefore remains 50.177 units of heat to be yet accounted for. But it is stated that the 898 lbs. of water supplied to the injector were heated from 52° to 117°, and this would, therefore, correspond to the absorption of $898 \times 65 = 58,370$ units of heat, or more than sufficient to account for all the heat lost by the steam. We, of course, do not for a moment suppose that any heat was created in the injector, and the fact that the amount of heat stated to be imparted to the feed-water exceeds by a small amount that lost by the steam, can only be due to some errors of observation.

Some of Mr. Bourne's experiments were conducted with the injector delivering against both higher and lower pressures than that at which the steam was supplied; indeed, in one instance the injector, when furnished with steam at 20 lbs. pressure, was made to deliver against a pressure of 100 lbs. In this case, however, the quantity of water which escaped at the overflow was equal to 80 per cent of that actually delivered by the instrument. It will be unnecessary that we should repeat the detailed calculation which we have made concerning these various experiments, but we may give, for the purpose of comparison, the results obtained in two instances in which the pressure against which the water was delivered were respectively much lower and much higher than that at which steam was supplied. These details are as follows:

	A.	B.
Duration of experiment....	9 min.	16 min.
Pressure in boiler	40 lbs.	30 lbs.
Pressure against which water was delivered.....	10 lbs.	90 lbs.
Quantity of water evaporated	6 gals.	6 gals.
Quantity of water drawn from supply tank	94 gals.	96 gals.
Quantity of water delivered into reservoir tank	100 gals.	100 gals.
Quantity of water escaped at waste pipe	..	6 gals.
Initial temperature of water,	60° Fahr.	52° Fahr.
Final temperature of water,	116° "	114° "
Units of heat abstracted from steam.....	60,245	60,320
Units of heat imparted to feed-water	52,175	57,766
Units of heat due to work done	29.8	268.5
Units of heat not accounted for above.....	8,040.2	2,285.5

In the case of experiment B, the 2,285.5 units of heat, entered as "not accounted for," were probably carried off by the water which escaped by the overflow pipe. It is worthy of remark, that in the two experiments, of which we give the particulars above, the same volume of water was evaporated and the same quantity delivered, notwithstanding that the circumstances were so different in the two cases. Inasmuch, however, as the temperature of 40 lbs. steam is 287°, and that of 30 lbs. steam 274.4°, the six gallons of water evaporated would, in experiment A, weigh 55.56 lbs., and, in experiment B, weigh 55.84 lbs. It is also probable that if the measuring arrangements had been sufficiently delicate, some other minute differences in the quantities would have been observed.

In conclusion, we think that Mr. Bourne's experiments fully corroborate the opinion which we have on many occasions expressed in this journal, that the injector, while forming an excellent and economical boiler-feeder, is not by any means adapted for raising water or for supplying water under pressure, except in those cases in which the heat imparted to the water delivered can be turned to useful account. While, however, we consider that Mr. Bourne's experiments

are of much practical interest, we cannot but regret that a supplementary series was not carried out with a donkey pump of good arrangement, substituted for the injector, the exhaust steam being utilized in heating the feed-water. Some useful comparative results might have been thus obtained, though we doubt whether the measuring arrangements were sufficiently delicate to enable the comparative efficiency of an injector or donkey pump for feeding boilers to be ascertained with accuracy. A thoroughly reliable series of experiments to determine this point is really required, and we trust that some day it will be undertaken. In the meantime our own predilections are in favor of the injector, always supposing that the use of that instrument does not necessitate the employment of cold feed-water where hot feed-water would otherwise be available.

WOODEN RAILWAYS.—During the late war in America the Confederates, in constructing temporary railways and renewing lines which had been destroyed, were compelled on many occasions to use wooden rails as the only kind procurable, and over these rails they transported altogether thousands of tons of baggage, etc., at what, all things considered, were very fair rates of speed. Wooden railways in fact, when properly made and worked, are by no means bad things in their way, and in countries where timber suitable for their construction is abundant, they may often serve a good purpose by opening up a traffic which as it increases will warrant the establishment of an orthodox iron road. It was a recognition of these facts which some nine or ten years ago led Mr. J. B. Hurlbert, an American engineer, to construct a wooden railway about six miles in length for light traffic, and the results obtained with this line proved so far satisfactory that early last year a line, 47½ miles in length, was constructed to connect Carthage, N. Y., with Harrisville. More recently, also, Mr. Hurlbert has built a line in Canada extending from the Clifton Iron Mines to the Otwegatchie Railway, a distance of twenty-two miles, and it is of this line that we more especially intend to speak here.

The rails of the Clifton Wooden Railway, like those of the Harrisville line already mentioned, are of maple, and are 14 ft. long, by 4 in. wide, by 6 in. deep. They should be laid "heart side" down. The sleepers, or "ties" as they are called in the States, are notched for a depth of 4 in. to receive the rails, and the latter are secured in the notches by wedges of maple plank 4 in. wide and 12 in. long. The switches are made in the usual way. The gradients on the line are in some places as steep as 1 in 15, and the sharpest curves are of but 250 ft. radius, these curves, however, being somewhat exceptional. The engines which have, until lately, been used on the line weigh 10 tons without wood or water, and their load averages from 30 to 40 tons. More recently heavier engines weighing 20 tons have been placed on the line, and it is expected that when the latter has been strengthened these engines will take loads of 60 or 80 tons over the railway from the mines to Ogdensburg, there being for this distance a general fall in the direction of the traffic, although the latter has to ascend in some places gradients varying from 1 in 68 to less than 1 in 60. It is stated, moreover, that on these wooden roads a 14-ton engine can draw easily 20 tons of freight up an occasional gradient of 1 in 21; and the experience of last winter has shown that ice and snow are no worse on a wooden railway than an iron one, the use of a snow plough and sand having enabled the Clifton line to be worked regularly in the winter season, even when the ground was covered with three or four feet of snow. The wheels of the rolling stock used on the line have rims similar to ordinary railway wheels, but a little wider, and the flanges are slightly beveled, so that they may bear against the rails without cutting them.) The trains are run at from 8 to 12 miles per hour, and these speeds can be maintained with safety; indeed, it is stated that no truck has been off the line since the Clifton Railroad was opened for traffic.

The quantity of maple used per mile for rails is about 22,000 c. ft., and it is stated that the cost for labor of placing these rails in position is from $80 to $100 States currency. Besides this, there is the cost of the "ties," and wedges, etc., and altogether it is stated that the complete cost of making and laying a wooden railway of a somewhat superior class to that of which we have been speaking, including a moderate allowance of rolling stock, sufficient for the traffic of the first few years, will not exceed $5,000 per mile. In many instances, in fact, such a line as the Clifton Railway can be

constructed, exclusive of rolling stock and large bridges, for $1,000 or £200 per mile. As regards the cost of maintenance, that, of course, depends mainly upon the amount of traffic; but in the case of the Clifton Railway, Mr. Hurlbert states that two men will suffice to keep in order three miles of line, replacing all worn rails that may be necessary. Altogether, we think that sufficient evidence has been afforded by the working of Mr. Hurlbert's wooden railways to show that such lines may be profitably constructed in many cases where, from the nature of the country, the formation of a regular railway would be scarcely warranted. It must be remembered, also, that a considerable portion of the labor involved in the building of a wooden railway could be turned to useful account whenever, from an increase in the amount of traffic, its replacement by an iron road became desirable, while the rolling stock, even if specially built for the wooden road, would also be available on the iron one.—*Engineering.*

AËRO-STEAM ENGINES.

From a paper read before the British Association by RICHARD EATON, Esq.

It is now pretty generally allowed that power and heat are convertible terms, and we have it upon the highest scientific authority that a unit of heat is equivalent to 772 foot-pounds. We are further informed that one grain of coal produces, by combustion, sufficient heat to raise the temperature of one pound weight of water through 1.634° Fahr. Taking the mechanical equivalent of heat at 772 lbs. per unit, as above stated, it follows therefore that the combustion of one grain of coal = 1,261.45 foot-pounds.

Now, with the best pumping engines, either on the "Cornish" or "Woolf" system, the average duty is equivalent to about 94,000,000 foot-pounds, with a combustion of 94 lbs. (1 bushel) of Welch coal; in other words, 143 lbs. per 1 grain of coal as compared with 1,261.45 lbs., whence it appears that the steam engine, in its most improved state, is not able to develop much more than one-tenth into *useful* power of the *mechanical* power due to the combustion of coal. As a rule, we may assume that the more distant the extremes of temperature in a thermodynamic engine, the larger will be the proportion of heat turned into power.

In the steam engine the extremes of temperature, or the difference in the temperature of the boiler and condenser, is *not* very great, and air engines, therefore, in which greater extremes may be employed, offer certain advantages in the production of power. But in their arrangement, construction, and practical working, many difficulties occur.

The difficulties in question arise, 1st, from the destructive action of the heating furnace upon the generator, which, when unprotected by water, is sooner or later burnt out or destroyed. 2d. When high temperatures of air are employed, the wear and tear of working parts becomes very great, and the difficulty of proper lubrication almost insuperable. On the other hand, if *low* temperatures be employed the engine develops but little power in proportion to its size, and the consumption of fuel becomes quite as large if it does not exceed that of ordinary steam engines.

In the consideration of the subject before us a useful lesson may be learnt from the avocations of domestic life. Let the tea-kettle be our monitor. The careful housewife places it duly cleaned and charged upon the fire, and no matter how sharp and clear may be the draught, nor how vivid and intense the gaseous flame, no harm ensues. Let her, however, neglect to keep it replenished, and what occurs—the bottom is destroyed. The water acts as a shield or safeguard to the metal exposed to the vivid incandescence, and in the present state of our knowledge as to the structure of metals, or their behavior when exposed to sharp heat, it is difficult to devise a better protection.

The difficulty above mentioned has hitherto proved insuperable notwithstanding the best efforts of those apostles and pioneers of the air engine—Stirling Ericsson and others. All the ingenuity expended upon the designing and construction of regenerators for utilizing to the utmost the heat of the escaping air, proved unfortunately of no avail so long as the generator, which was the mainspring of the whole, to say nothing of the working cylinder itself, remained liable to premature destruction.

Mr. George Warsop, of Nottingham, as the son of an air-gun maker there, was born with aerial ideas, which, although his only education was received at a Sunday School, and he was sent to work at ten years of age,

he turned that education to such good account that before he was twenty he had in leisure moments secretly constructed an air engine. Later in life it was his privilege, whilst a working mechanic in New York, during his engagement with Mr. Ericsson, to observe the weak points in the system of that highly gifted and persevering inventor, and after years of research to supply the deficiencies by a marvelously simple system of mechanism, which, as far as present experience goes, promises complete success by means which, happily for the cause of economy and progress, are compatible alike with physical science and mechanical construction.

It is proposed, firstly, to describe these means; secondly, to enumerate the carefully ascertained comparative results which have followed their application; lastly, to show that these results are in accordance with sound theory.

In the first attempts at practically carrying out the system, the arrangement adopted was an ordinary high-pressure engine, with vertical boiler, as used in the midland counties, where fuel is cheap. An air-pump is added, which is put in operation by the action of the steam engine.

Thus, cold air is taken in by the air-pump, and is forced on in its compressed state through an air-pipe, which, in the case before us, is connected first within the exhaust, then in a coiled form down the funnel of the boiler, then past the fire, and finally past a self-acting clack valve at the bottom of the boiler into the boiling water itself, rising naturally through the water, the air is intercepted and subdivided by diaphragms of metal gauge. Thus a two-fold service is rendered by the contact of the elements, the water becoming acrified and deprived of its cohesion and prompted to a free ebullition, whilst the air on rising above the water is saturated by the steam, and the two together pass on to their duty in the cylinder, where saturation assists lubrication. The agitation of the water prevents scaling.

The machine thus constructed, but having two air-pumps, and with cam motions applied to the valves as also to the poppet valves of the working cylinder, gave the following results, results which it must be admitted were sufficiently discouraging to have deterred the inventor and his associates from proceeding further in the matter, but for their faith in the intrinsic soundness of the system, and perseverance in carrying it to a practical issue. The work had to be done under disadvantages of various kinds, on inconvenient premises, which centuries back were a farmhouse standing within the ancient walls of Nottingham, and until the protection of the patent laws had been obtained, the original apparatus was carefully guarded in an unsuspected attic.

The results I proceed to detail:

TABLE NO. I.

Combined Air and Steam Engine.

Coals consumed during experiment.	Weight on brake.	Duration of experiment.	Number of revolutions of brake.	Number of revolutions of brake per minute.	Gross H.P. of useful work done.	Gallons of water evaporated during experiment.
lbs. 110	lbs. 75	min. 140	4,623	33	182	84
Steam Engine only.						
lbs. 110	lbs. 75	min. 115	5,182	45	204.1	66

It is needful to state that the amount of air passed in the boiler in a state of compression was considerable, being as much as 43 per cent of the effective cubic contents of the working cylinder, or consumption of combined fluid from the boiler. And it appeared pretty certain that the power obtained by the increase of volume of the air admitted (due to the treating of it), did not compensate for the power consumed in working the two air-pumps which forced it into the boiler. At the same time the difference in the useful effect in the two modes of working did not appear to be so great as the power required in handling the pumps led one to suppose it would be. Hence, there appeared an evidence of a certain latent gain which needed only development. To effect this, one of the air-pumps was discarded, and experiments made by means of waste holes drilled through the walls of the remaining one to ascertain what proportion of air admitted to the boiler fully compensated for the cost of compression. And it was found that about 10 per cent of the effective consumption of fluid in the working cylinder gave much more favorable results. At the same time the cam motions were discarded, and the air-pump valves left to their own unaided action. The results are given in the subjoined table:

TABLE NO. II.

Combined Air and Steam Engine.

Coals consumed during experiment	Weight on brake.	Duration of experiment.	Number of revolutions of brake.	Number of revolutions of brake per minute.	Gross H.P. of useful work done.	Gallons of water evaporated during experiment.
lbs. 140	lbs. 124	min. 195	8,463	43.4	551 1	104.3
Steam Engine only.						
lbs. 140	lbs. 124	min. 145	5,912	41	366.9	64

Percentage of gain in work done by combined engine, as compared with that done by steam only, 42½ per cent.

Here, although a very remarkable relative economy was apparent, it became obvious, on consideration, that danger of mistake would arise in assuming this economy as absolute, inasmuch as the duty performed, when contrasted with that obtained from engines of standard types, actuated by steam, was manifestly low, and it seemed probable that, as by judicious improvement in details, the duty was made to approximate more closely to fair steam-engine duty, this relative economy might fall off considerably, inasmuch as there would be less margin to economize upon.

With the view of testing this point, and also for the satisfaction of railway engineers, of conducting experiments at locomotive pressures, a thorough remodeling of the whole apparatus was effected. The tappet motions were thrown aside in favor of the usual slide-valve arrangement, working with a moderate amount of expansive action. The former wasteful vertical boiler was discarded in favor of a more economical one, of the compound or Cornish multi-tubular description, so as to obtain a better evaporative duty from the coal consumed. The radiating surfaces of the cylinder pipes were re-clothed, and the feed-water heated by the exhaust steam. Instead of exposing the air-pipe to the direct heat of the furnace, as in the former case, the air became thoroughly heated on its passage from the pump to the boiler to a temperature of from 500° to 6,000° Fahr., by being conducted through suitable coils and pipes through the exhaust steam in the heater, and the waste heat in the boiler flues and uptake.

The general arrangement adopted is shown by the accompanying drawings. The air is forced by the air-pump through a tube of ordinary wrought-iron, and of 1¼ in. internal diameter, into coils in the regenerator, which is heated by the exhaust steam, thence in a straight line to the uptake, down which it passes through a coil into the flues beneath the boiler, and through another coil in the smoke-box, thence back to the front of the boiler and past the clack valve, and is led down by an internal bend to the bottom of the boiler water space, where it is evenly distributed along the whole length by a perforated pipe, and the results are given in the following tables, Nos. III and IV:

TABLE NO. III.

Combined Air and Steam Engine—Even Pressure trial.

Coals consumed during experiment.	Weight on brake.	Duration of experiment.	No. of revolutions of brake.	No. of revolutions of brake per minute.	Gross H.P. of useful work done.	Gallons of water evaporated during experiment.	Weight of fire left in furnace when engine was stopped.
lbs. 112	lbs. 120	min. 153	15,433	nearly 101	972.55	93¾	lbs. 53½
Steam Engine only.							
lbs. 112	lbs. 120	min. 112	10,500	93¾	661.69	68¾	lbs. 34

N. B.—These trials were conducted on the same principle as that followed by the Royal Agricultural Society, the engine being stopped in each case when it ceased to perform 90 revolutions per minute.

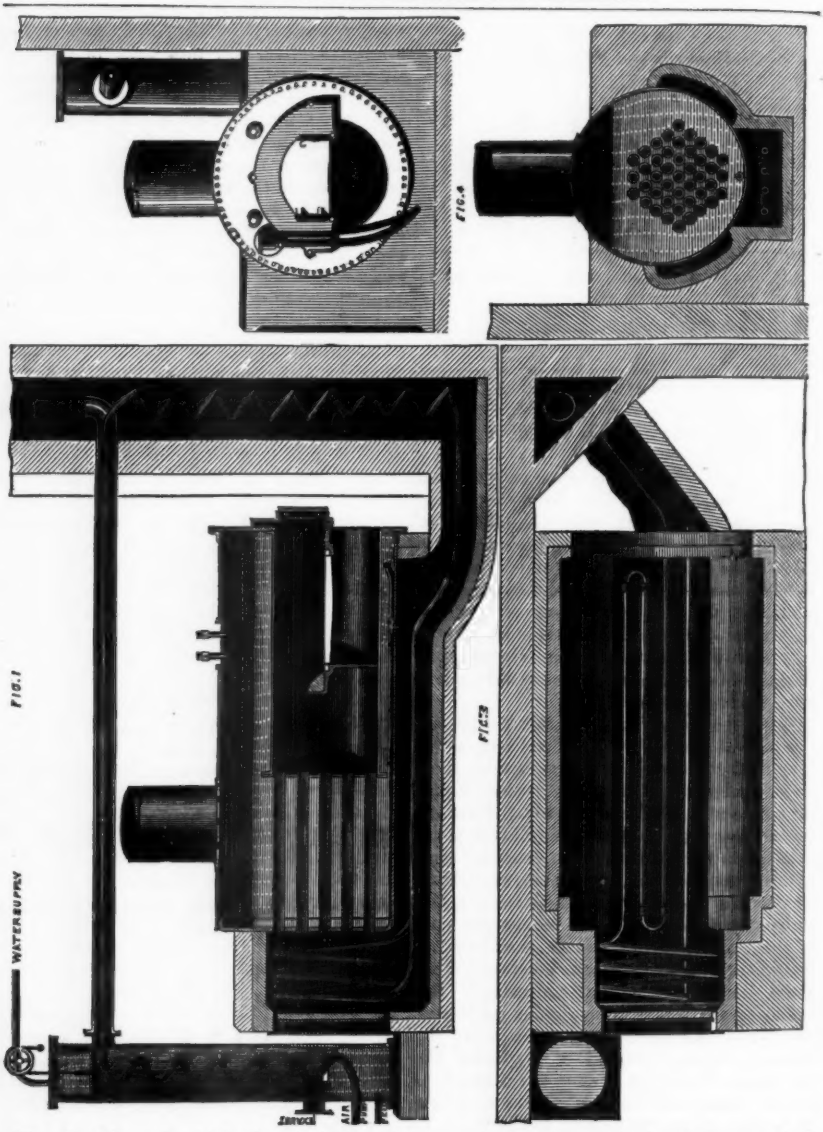
Percentage of gain in work done by combined engine, as compared with that done by steam only, 47 per cent.

TABLE NO. IV.

Combined Air and Steam Engine—Open Valve trial.

Coals consumed during experiment.	Weight on brake.	Duration of experiment.	No. of revolutions of brake.	No. of revolutions of brake per minute.	Gross H.P. of useful work done.	Gallons of water evaporated during experiments.	Weight of fire left in furnace when engine stopped.
lbs. 140	lbs. 120	min. 234	22,815	97.5	1,428.05	131.25	43
Steam Engine only.							
lbs. 140	lbs. 120	min. 196	17,825	90.94	1,115.7	112.5	lbs. 28¼

Percentage of gain in work done by combined engine as compared with that done by steam only, 27.994 per cent.



The pipe through which the air is forced into the boiler by the action of the air pump is of iron, and is $1\frac{1}{16}$ in. in diameter outside, and $1\frac{1}{4}$ in. bore. On leaving the pump the pipe is first led to the heater, shown on the left of the engraving, wherein it is exposed to the exhaust steam. The heater consists, as will be seen, of a cast-iron cylindrical vessel placed in a vertical position, and provided with two branches—one near the bottom and the other near the top—through which the exhaust steam respectively enters and escapes from the casing. At the top of the heater is placed a small cylindrical tank exposed at the bottom and sides to the exhaust steam,

and perforated around the upper part of the sides, so that in the event of its receiving an excess of water, the latter may overflow and fall to the bottom of the heater. Through a stuffing-box at the bottom of the tank there passes a tube provided with a rose at the lower end, this tube being carried by a float, which swims in the water at the bottom of the heater, as shown, and, by means of a cord passing from the top of the tube, works a cork, which regulates the supply of water to the tank at top of the heater. The action of this heater will be readily understood without further explanation, and we need merely add that it furnishes a steady supply of hot feed-water at a temperature of from about 195° to 200°.

The air-pipe, after leaving the heater just described, passes along the exhaust pipe to the chimney, and descending the latter spirally, as shown, passes into the flue beneath the boiler. Here it is led backwards and forwards, as shown in the plan, and after making several convolutions in the smoke-box, is led back to the front of the boiler, where it communicates with a valve-box containing an ordinary light clack-valve. The object of this valve is to prevent water from entering the air-pipe when the engine is stopped. From the valve box a pipe is let down within the boiler to the bottom of the latter, this pipe being perforated at intervals on the upper side. The perforations are placed closer together at the further end of the pipe than they are at the end at which the air enters, and by this means an equable distribution of the air at the different parts of the boiler is insured.

The lengths of the various portions of the air-pipe are as follows: In feed-water heater 12 ft.; in exhaust-pipe 13 ft. 6 in.; in chimney and flues, including coils in smoke-box and under boiler, 58 ft.; total, 83 ft. 6 in. The total external surface exposed by this pipe is thus about 36¾ sq. ft.

The principal dimensions of the boiler are as follows: Length, 8 ft.; diameter of shell, 3 ft. 6 in.; diameter of fire-box flue, 2 ft. 2 in.; length of fire-box and combustion chamber, 5 ft.; and length of tubes, 3 ft. The tubes are 41 in number, most of them being 2⅜ in., and some of them 2 5/16 in. diameter. The total effective heating surface exposed by the boiler is about 130 sq. ft.

It is right to mention that in all the before detailed experiments, the "Prony" brake with the best modern improvements was used as the measure of useful work done, and *every care* taken in the conduct of these trials to determine accurately the amount of water evaporated, and the duty done in useful effect by a given amount of fuel.

Other observations as to temperature, indicator diagrams for determining the cost of the air compression in proportion to the power developed, and various useful notes were obtained, which it would be out of place to recapitulate here at length, but all these details are at the disposal of the Association, or any scientific persons interested in the subject.

Professor Tyndall has volunteered to investigate the scientific bearings of the results which have been personally observed in Nottingham by that accomplished amateur engineer, Lord Richard Grosvenor, and by other engineers, several of whom have already applied to be licensed to make.

It remains to submit to your consideration the theory of our system. We have here a machine which, when worked as an ordinary steam engine and boiler, performs as respectably in its brake duty as an average well-constructed commercial engine, not designed to work with a high rate of expansion, and we find that the addition of the pneumatic arrangements considerably enhances the amount of its useful duty.

Let us now endeavor to ascertain in what manner the gain in question arises, premising that the following condition of things can exist only in theory. Suppose a boiler to be theoretically perfect, wasting no heat, and its feed level maintained only just constant, the quantity of water evaporated being infinitely small, and friction of all kinds to be eliminated in the machinery. Then the power required in compressing any given amount of air at atmospheric density will be recouped by the power generated by the re-expansion of the air so condensed, action and re-action being equal.

Let us now ascertain the cost of obtaining a given quantity of steam at a given pressure, as compared with the like quantity of air at the like pressure, and for the sake of example we will take 150 c. ft. in each case at 60 lbs. pressure per square inch in gauge. Here the relative volume of the steam to the water which generated would be in the case of 60 lbs. pressure (307° Fahr., about) = 355 to 1, according to Regnault. And it follows that the 150 c. ft. of steam under consideration was generated from 1.355th of its volume of water originally, or .422 c. ft.

The weight of one cubic foot of water being 62.32 lbs., the weight of .422 c. ft. would be 26.3 lbs. Now, to raise 1 lb. of water from 62° Fahr. to 212°, or through 150°, requires 150 heat units; to convert it from water at 212° into steam at any pressure, 966 heat units; total gross units, 1,116; and as the conversion thus of 1 lb. of water requires 1,116 heat units, it would follow that the conversion of 26.3 lbs. of ditto would require 29.350 heat units, which is the cost of obtaining 150 c. ft. of steam at 60 lbs. pressure. In the case of the air, 500 c. ft. of atmospheric density and temperature, 62° would, by Mariotte and Dulong's law, be transformed into 100 c. ft. at 60 lbs. per sq. in. on gauge, supposing the temperature remained unchanged. But this 500 c. ft. of atmospheric air is, by the combined agency of the increase of temperature, due to compression and the application of artificial heat in some form brought from its original temperature of 62° up to that of the boiler, viz: (that due to 60 lbs. pressure,) 307°; in other words, through 245° Fahr. Now, the weight of 500 c. ft. of atmospheric air = 38.05 lbs., that of 1 c. ft. at atmospheric density and 62° temperature being = .761 lbs., according to Regnault's experiments. And we have seen that this 500 ft. at atmospheric density, and 62° temperature, is equivalent in value to 100 c. ft. at 60 lbs. pressure and the like temperature, the weight therefore would be alike = 38.05 lbs.

The increase of volume from 100 c. ft. due to the increase of temperature from 62° to 307°, or through 245° would be, according to the general formula applicable to the expansion of gases, about 50 per cent, or, say roughly, as the volume would increase 1-480th of its bulk for each degree Fahr. increase of temperature; for 245° increase, the original bulk, 100 c. ft., would be increased 245-480ths, which is about 50 per cent, the original 100 c. ft. at 60 lbs. pressure per square inch now becoming 150 at the like pressure, and this weighing 30.05 lbs. The number of units of heat which will be consumed in raising the temperature of this 38.05 lbs. of air from 62° to 307°, or through 245°, the pressure remaining constant and the volume variable, as above described, will, according to Regnault, bear the same to that which would raise the same weight of water through the same amount, as 238 to 1.

38.05 lbs. × .238 × 245° range through which raised = 2,218.69 heat units, which is the cost of obtaining 150 c. ft. of air at 60 lbs. pressure, as compared with the 29,350 heat units before mentioned in the case of the like quantity of steam, a very striking and remarkable difference. Both these 150 c. ft. are capable, when worked in a cylinder, of generating the same motive force, and are alike capable of being worked expansively, but it is an important consideration whether the loss in working the air expansively would not be greater, owing to its more rapid radiation and loss of heat and consequent loss of volume and pressure.

A further series of experiments are about being made with the view of ascertaining the results due to working at higher pressure and rates of expansion, and here thorough jacketing and maintenance of the temperature of the working cylinder will doubtless prove most valuable.

Such a theoretical gain, viz: about 13 to 1, is evidently vastly far from being realized in the experimental engine, seeing that only about 13 per cent of the whole cylinder consumption in the last experiment is passed into the boiler (in place of 100 per cent, as in the investigation above given), the remainder being supplied by the steam generated, thus 13 per cent air + 87 per cent steam; and we must look to other causes, in addition to the above, to account for the economy realized in practice. It is conceived that it is to the injection of air into the boiler that this may mainly be referred for the following reasons. When steam is ordinarily raised from water, the heat expended is consumed partly in overcoming the cohesion of its particles, and in creating steam room for the vapor raised, and, further, in promoting the circulation of the water itself in the boiler. In all of these operations work is done, and the injection of the air accomplishes practically the work which, under the above mentioned circumstances, would have to be done by the heat, a much more intense and rapid circulation of the water is achieved, and the rapid ebullition and giving off of steam bubbles is greatly promoted. Further, the air enters at a high temperature, and its *direct* action upon the water is equivalent to an increase of evaporative surface, all the more efficient from being direct instead of communicated by the conductive power of metal plates. It is to be regretted that some more certain method than the usual high grade thermometer has not yet been devised and applied

for, measuring the temperature of the incoming air, which is the best absorbent of waste heat in the boiler flues, which can well be devised, and, according to present experience, a very perfect agent in transmitting it into mechanical force. In short, the change of condition which occurs in the boiler immediately on the admission of air may be best realized by imagining the tubes and tube-plates to be suddenly removed and replaced by an indefinitely large number of tubes of infinitely small diameter, permeating the water and increasing the ebullition and disengagement of vapor bubbles by an agitation almost mechanical.

An experiment, which has been repeatedly made, goes far to confirm this view. Let the engine be running under steam, the pressure gauge rapidly falling, with the fire fast dying out, the putting the air-pump in gear will cause the gauge to mount several pounds in the course of a few minutes, and there continue for a considerable time, the engine meanwhile continuing to work as before, after checking a moment or two on first feeling the increased resistance due to putting the air-pump in action. And this result evidently shows that the evaporative duty of the boiler is increased immediately on the admission of the air, and irrespective of the state of the fire—a state of things which is consistent with the foregoing explanation, and, indeed, scarcely susceptible of any other.

Even did time permit, this possibly is not a fitting occasion for more than a passing glance at the social or commercial bearings of this discovery. As our navy and Government workshops can thereby be coaled at far less cost than hitherto, taxation may be reduced. Agriculture will be an immense gainer in the impulse given to steam cultivation in all its branches, no trifling consideration in view of the fact that in the month of May last one English firm turned out 102 portable engines. Manufactures of all kinds, where steam-power is used, will be cheapened, the sailing vessels of our mercantile marine will be rapidly transferred into auxiliary steamers able to traverse the Suez canal and the Red Sea, towards which all eyes are now turned. Communication with all parts of the world will be cheapened and facilitated. There are good grounds for expecting that railway dividends will improve. It is estimated, by way of example, that the Metropolitan line would save £6,000 per annum in fuel and water, whilst the ventilation of its tunnels would be improved, and the additional power, gained at a trifling outlay, would enable each engine to draw two more carriages than at present. Our mines, our water-works, our drainage operations, and our quarries will share in the general gain. Our mechanics, now quitting, with weeping eyes and aching hearts, the land of their nativity, because they have no work, will have enough and to spare, through the impulse given to the construction of new engines and the adaptation of old ones. Nor will the colliery-owner suffer, as is proved by the cordial satisfaction already expressed in that direction.

Opportunely does this discovery come in 1869, the centenary of the steam-engine.

A writer, in a recent number of that valuable paper, the "Economist," remarks that "a single improvement, to save 10 per cent in fuel for the steam-engine, would probably add more absolutely to the real wealth of this generation than the invention of the steam-engine itself added to the real wealth of the generation in which it was invented." After years of anxious research we now possess such an improvement, but of greater value. We are thankful for the opportunity of doing good in our day and generation.

THE REMOVAL OF SILICON FROM PIG IRON.

Abstract of a paper read by Mr. J. PALMER BUDD, before the Iron and Steel Institute.

In the Welsh ironworks, the pig iron is principally white. The whole of the forge cinder made is put on the blast-furnaces; and cinder in large quantities is purchased in addition from the tin plate and other neighboring forges. A large admixture of Lancashire and Cumberland and other hematite ores is put on the furnaces as a corrective. The furnaces are driven hard; and the white is of course inclined to be sulphury. The plan of working is to refine, before puddling, from a half to a third of the white in refineries placed before the blast-furnaces, potting the iron into them. The yield of these fineries from molten iron is about 23 cwt. of pig or cast iron to the ton of refined metal; the consumption of coke is 5 or 6 cwt. to the ton; and the total expense of the refinery process from 10s. to 15s. a ton. In some works the puddling furnaces have one-half white pig and one-half refined iron; in others, the proportion

is one-third refined metal, one-third white pig, and one-third mine pig, made without cinder from argillaceous mines and hematite ores. Soft Lancashire ore is freely allowed for fettling the puddling furnaces. The popular notion is, that the white iron is decarbonized in the refinery process, and freed from sulphur and phosphorus. Messrs. Crace Calvert, and R. Johnson, Dr. Percy, and other authorities, have shown conclusively that this popular notion is unfounded. They have proved that all cast iron contains a notable proportion of silicon varying from 1 to 6 per cent (the grayer the iron the greater the proportion of silicon), which is reduced in the blast-furnace, and combined with the iron from its earthy base, silica.—It is silicon which imparts its casting property to pig iron; when removed, cast iron is only semi-fluid, although it may retain all or nearly all its carbon. From its greater affinity for oxygen than carbon, silicon protects the carbon in pig iron from the action of oxygen; even when it is present in the small proportion of 1.500 per cent no carbon is burnt off. Silicon is, in many of its properties, very analogous to carbon; and the refining process instead of being called a decarbonizing, might be better described as a desiliconizing of the iron. Now, the process he had invented desiliconized the iron as tapped from the blast-furnace without wasting the iron, and without any extra expense whatever beyond the usual cost of the pig; nay more, it was more economical to make than pig iron. The process must therefore revolutionize the present practice in the iron trade. His usual mode of proceeding was to place a series of iron moulds similar to those used before a refinery, as near as convenient to the top hole of the blast-furnace. He made a paste by moistening with water soft hematite ore, which, if gritty, is previously ground, and he threw a bucketful, containing about 60 lbs., into the mould in a semi-liquid state, and spread it evenly on the bottom and sides. The mould being quite hot from the previous cast, dries the paste, which adheres to the bottom. He then pots as much iron as is required from the blast-furnace, and allows it to run over and fill the moulds to the depth of three and a half to four inches. A great ebullition took place; jets of flame of a peculiarly white color burn on the surface, which he assumed to be the combustion of silicon in the oxygen abstracted from the hematite. It was proved by repeated analysis that whilst the silicon was 1 per cent in the white cast iron, it is reduced by this simple process to .200 to .300 per cent, or from 1 per cent to 1-500th, a cinder is thrown up containing silicon, some phosphorus, and sulphur. The carbon is hardly at all removed. The appearance of the iron after the process is that of refined metal.—For want of a sufficient upward impulsive force, a good deal of the scoriæ, although chemically separated in the process from the iron, is not removed from it mechanically, but is mixed with the refined metal; and, on remelting in a puddling furnace, forms a protecting slag. The cost of the process is nil, as the iron contained in the hematite is reduced, and adheres as cast iron to the bottom of the iron in the mould. There is no sand or coke dust used; and the refined iron goes clean into the puddling furnace. The yield in puddling is, that of refined iron, about 21 cwt. to the ton of puddled bars.—The puddlers like to have one or two pigs of white, with the metal so refined, as they say it works more "liquory"—showing that when the silicon remaining is only .200 or .300 per cent, the charge does not possess the necessary fluidity. The puddling furnace keeps longer in repair; no other fettling is used; and hammer slack and the former allowance of shearings to make scrap balls has been discontinued. The men do more regular work; and, like the refined iron, the yields are larger. The puddled iron is of an improved quality, and much liked in the rail mills. The second process was the same as the first, only that he mixed two-fifths by weight and half by bulk of nitrate of soda with the hematite ore, which is formed into a paste, and applied in the same way. With this mixture, the ebullition is greater; the flame is of a yellowish color—showing the ignition of some of the soda. The cinder is thrown up and out of the iron, over which it forms a crust, which can be separated when cold. The iron has a cellular and honey-combed fracture, like metal much over-blown. The scoriæ contain sulphur, phosphorus, silica and soda. The iron works drier and cleaner, and to a better yield than that made by process number one, but should have about one-third of gray pig added to make a very clean and rough iron. The only cost of the process is the nitrate, which in the proportion named comes to about 4s. per ton at its present high price. The saving by the process was very considerable, and it was not confined to

white iron, though it was then most efficacious. The author added: "In my opinion, the money value of my invention to the iron trade will be enormous; greater, perhaps, than that arising from the use of the blast-furnace gases, said to be a £1,000,000 a year, and which I first introduced into this country and made known to the iron trade at the meeting of the British Association held at Swansea, in 1849."

ASPHALTED SURFACES.

From the "Mechanics' Magazine."

A mixture of the ordinary coal gas tar and common gravel constitutes nine-tenths of the so-called asphalte, and it is no wonder, when the spurious article is passed off for the genuine, that the latter suffers in the estimation of the public, and many refuse to believe in the durability and efficiency of an asphalted surface. This is the natural result of the very cheap and very bad footpaths and platforms that have been laid down in numerous localities and composed of the ingredients referred to. A surface thus constructed will, in spite of the imperfect nature of its components, if the formation of it be carefully attended to exist for a time in a smooth and apparently sound condition. This appearance is, however, deceptive. The influence of wear and tear, combined with the action of wet, speedily produces hollows and irregularities, cracks and crevices extend their ramifications in every direction, and the opposite effects of heat and cold are equally active in the work of disintegration and destruction. The one renders it sticky in summer, and the other brittle in winter; the whole mass soon breaks up and has to be removed, to the loss and disgust of those who laid it down, and who register a vow never to employ "asphalte" again for any purpose whatever. If we now consider the difference between the spurious and genuine articles, it will not be surprising that the former has no claims to the title that belongs properly to the latter. Instead of being the hasty result of a mixture of tar and sand or gravel, the genuine asphalte has a very different composition. Its chief ingredient is derived from a natural production, drawn from foreign quarries, or mines as they are generally termed. At present, there are very few of these mines, of which the best known is probably that of Pyrimont. The raw material arrives in the form of dark-colored amorphous lumps containing a large proportion of bitumen, which is extracted by the employment of suitable mechanical means. One of the principal components of bitumen, according to the nomenclature of M. Boisingault, is the substance asphaltene. It has a chemical composition represented by the formula $C_{20}H_{7}O_{2}$, and we recommend it to those whom it may concern as an excellent name whereby to distinguish the genuine from the spurious article. When it is kept in view that, in order to obtain a material fit for manufacturing asphalte as it ought to be made, it is necessary to import the chief ingredient from Italy, it is evident at a glance that there will be a wide difference in the price of the foreign and the home production. As the price, so is the quality. A permanency and durability are obtained by the use of the extracted bitumen which cannot be expected from the wretched stuff prepared from the ingredients to which we have alluded. At the same time, it is equally necessary to ensure good and sound workmanship in the laying down of asphalte as to provide the best materials. There is a company which has portable machinery, especially designed and constructed for this purpose, which allows of a large area being covered in a comparatively short space of time. As we have deprecated the use of bad and inferior asphalte as exceedingly deceptive to the public, and prejudicial to the prospects of the only proper substance, it is but fair to give a few instances where the latter may be seen and its value appreciated. One of these is, in the words of Mr. Hepworth Dixon, "Her Majesty's Tower." Most of the footpaths, and some portions of the roof, have been laid for some years past with Pyrimont asphalte, and yet present no signs of deterioration. The roof of the new prison at Holloway, and the extensive footpaths around the fountains in Trafalgar-square, are other examples.

According to the climate and the purposes for which it may be intended, so can the composition and character of asphalte be varied. From its nature, it must always possess some little elasticity, even when that quality is required to be reduced to a minimum. This is one of its properties, which is frequently of considerable advantage. It renders it exceedingly valuable as a "damp" course in buildings, and much superior to slates, tiles, concrete, or other hard and unyielding substances. Considering them all on a par with respect to water-proof

qualities, the asphalte alone possesses the capability of yielding to any local pressure. Consequently, if any portion of the foundation settle, the slates, tiles, or other hard substances at once break across, and the watertight continuity is destroyed. The asphalte, on the contrary, adapts itself to the settlement of the foundations, and preserves the water-proof layer intact. Any one who has walked over a large area of properly executed asphalte cannot fail to ask himself the question, whether its application could not be extended to road and street traffic. There is no doubt but that the substitution of asphalte for granite or macadam would be hailed with ecstatic delight by the riders of bicycles. What a road to run on! A portion of Threadneedle-street has within the last nine months been laid down with asphalte, but upon a different principle to that upon which footpaths are constructed. Some time must elapse before it will be possible to judge of the suitability of this surface for the severe tax made upon its powers of resistance and durability by the exigencies of our metropolitan traffic. There is another situation for which an asphalted surface appears to be well adapted, and in which its property of elasticity can be advantageously brought into play. It is in the case where it is necessary to form a footpath on made ground. The most extensive example of this kind is probably to be found in the foot thoroughfares of the Thames Embankment, and any one who is in the habit of traversing that on the north side cannot fail to perceive how badly the paving flags adapt themselves to the irregularities caused by the "giving" of the ground underneath. A very slight subsidence, which would be scarcely appreciable under ordinary circumstances, is quite sufficient to destroy the evenness of a flagged footway. As it is, many of the flags are disturbed to an extent which throws up one end fully an inch above its neighbor, and imparts a very jagged appearance to the surface. Taking them up and relaying them is the remedy, but how often this remedy will have to be repeated it is impossible to assert, for railway experience has demonstrated that it frequently requires a long time for a heavy embankment to settle permanently to its "bearings." In pointing out the manner in which paving flags behave under the conditions in question it is not intended to assert that they ought to be replaced wholesale by an asphalted surface, but had a small portion of the Embankment been covered by the latter substance, the relative merits of the two descriptions of paths would have been fairly and impartially tested. The principle of giving every method of executing any particular description of work a fair trial is one that needs urgent adoption by the various branches of our civil and military departments. By every method is signified every one that possesses manifest claims to consideration, and does not, of course, include the mere ideas of inventors, or hobbies of patentees which are destitute of all practical utility. But, when an individual or a company is willing to test, solely at their own expense, any plan they consider likely to effectually accomplish any desired object, they ought to be allowed to have an opportunity of so doing. It might be urged that the public ought not to be put to any inconvenience with respect to interruption of the ordinary traffic, supposing the trial concerned the taking up of any part of a street or thoroughfare. What with gas and water companies who are perpetually breaking up the streets, the public is pretty well used to such inconveniences. Moreover, as the object of all proposed improvements is to benefit the public, the end fully justifies the means. There are undoubtedly many valuable inventions totally lost to us solely because we never permitted them to be fairly and dispassionately investigated, and their practical merits submitted to the crucial test of actual experience.

SIEMENS' REGENERATIVE FURNACES.

Abstract of paper read by Mr. JOSIAH T. SMITH before the Iron and Steel Institute.

Although, the writer said, this subject had been brought before various societies since 1862 by some of the most eminent men of the day, and for many years had been in extensive and successful operation in various processes connected with manufactures, both at home and abroad, it had, with very few exceptions, not been adopted in the iron and steel works of Great Britain. It was possible, however, that in a few years those districts which contained large quantities of inferior coal or fine slack, without sufficient bituminous principle to make it available for cooking purposes, would find that they possessed, by means of the above invention, the opportunity of supplying their requirements from such sources. While in this country

it was probable that coal would exclusively be used to produce the gaseous fuel required for the regenerative furnace, in France, Belgium, and Spain they merely used wood; in Germany lignite, and peat in Italy. It was believed that the first idea of storing waste heat to be used at intervals was due to Dr. Stirling, of Dundee, who, in 1817, patented the regenerator or heat accumulator, and subsequently applied it to his caloric engine. Captain Ericsson, in 1851, also used a kind of regenerator to his air engine; but Siemens had previously, in the years 1847-8-9, taken out patents for his regenerative steam engine and condenser. None of these inventions ever came into extensive practice, and not till 1862 did the discovery really assume a shape which was at all attractive. The invention might be generally described as requiring a producer —for the volatilization of coal, wood, peat, and such like products into gases—which might be erected at any practicable distance from the furnaces to which they were to be applied; while a regenerator, divided into four compartments filled with loose fire-bricks, had to be placed under the furnaces. These regenerators were simply fire-brick chambers divided into four compartments, one on each side for the passage of gas, and two in the centre for air, with generally five ports at each end communicating with the furnaces above. The chambers were filled with fire-bricks placed in a chequered manner, and while the upper portion had to be of the best quality, those beneath would answer if they were of the most inferior description. The chemical action which took place in the producers was described by Mr. Siemens in his lecture before the Chemical Society as follows: "Air is admitted at the grate and as it rises slowly through the ignited mass, the carbonic acid first formed by the combinationof the oxygen with the carbon of the fuel takes up an additional equivalent of carbon forming carbonic oxide, which, diluted by the inert nitrogen of the air, and by a little unreduced carbonic acid, and mixed with the gases and vapors distilled from the raw fuel during its gradual descent towards the grate, is led off by the gas tubes to the furnaces." The temperature of the gas at the junction of the upcasts with the tubes was 1,250 to 1,300 degrees Fahrenheit, a rather higher point than had yet been noticed. Before it had traveled 200 ft. in the tube, with an external atmosphere of 60 degrees, the temperature was reduced to about 130 degrees. He had himself been unable to ascertain the exact quantity of heat lost by radiation in the interval, but the experiments, although not complete, were sufficient to show that the quantity was so small that at present he could see no way of economically applying it. This lowering of the temperature and condensation of the gases was of advantage in many respects. The gas being heavier, caused, in its transit through the tubes and the various downcasts, a syphon action; and thus not only drew the gas from the producers to the furnaces, but, by keeping up a slight outward pressure, prevented the admission of air through any crevice in the tubes or the expansion boxes. It also deposited the tar from the coals into a series of wells beneath; while the water in the fuel was also condensed, and thus prevented from causing a waste of metal by introducing a too great supply of oxygen into the furnaces. After noticing more in detail the application and effect of the gases, Mr. Smith added that for many months each producer at Barrow had volatilized 3 tons of coal per 24 hours, and that the greatest economy effected was when the consumption had not exceeded 50 cwt. Estimating the weight of one cubic foot of gas at the ordinary temperature of thin air to be .075 lbs., the volume of carbonic oxide, hydrocarbon, and hydrogen, from one ton of coal would be about 53,000 ft.; and the volume of nitrogen about 122,000 ft., or making together a total of 175,943 ft. The consumption of coal in the producers at Barrow being 500 tons per week, it gave an amount of gas passing through the tubes at the rate of $6\frac{1}{2}$ ft. per second, of 87,000,000 cubic feet; or through the various furnaces, adding the quantity of air there admitted, of 6,600 tons. The saving of fuel by this process at Barrow was, over a period of two years, no less than 44 per cent; but the actual money saving, by the use of a particular kind of coal, had been more than one-half. The yield of the gas furnaces, taken over the same period, showed a saving of 31 per cent as compared with the work at the firing furnaces, and the amount of repairs was just two-thirds of the old cost. In these three particulars was undoubtedly to be found the chief economy; but the adoption of the system enabled them to preserve greater cleanliness and order in their works, and an entire absence of smoke met a difficulty which in the neighborhood of large

towns, was every year becoming a greater grievance. There was, he admitted, a slightly increased outlay on the plant; but taking into consideration the increased capabilities as to quantity, it would be found to represent the difference in cost between the two systems.

RAILWAY WORKING.

From "Engineering."

A given line of railway has, say, 5,000 passengers, on the average to be carried daily. Whatever pair of factors of this number be taken, one represents the number of passengers per train. There may be ten trains with five hundred passengers in each, or five hundred trains with ten passengers in each; or, intermediately, fifty trains with one hundred passengers in each. As for "railway economy" there can be no question as to which of these three divisions of daily traffic would best pay the shareholders, but it is equally clear that the ten trains, of five hundred passengers each, would not suit the imperative requirements of public convenience. The passenger wishes to hail a train much as he would hail a cab. Nothing would suit him better than to have it all to himself, or to himself and his friends. So there must be a compromise somewhere. It will neither do to run a train, or even a special carriage, for every passenger who has an important engagement, and who must, or thinks he must, be off at once, nor will it do to keep equally impatient passengers waiting for even an hour so that five hundred may be packed off together. Somebody has put forth a pamphlet, from the manager's and shareholder's point of view, arguing that fewer and better filled passenger trains are essential to the recovery of railway property. The Times comes down promptly upon it, arguing, in substance, but with perhaps less force, that passengers must have trains in waiting for them whenever they happen to want them, and that if A finds it necessary or convenient to go at 11 a.m., B has a right to a train for himself at 11.5 or 11.10, and C, if not prepared to go with either, should have his train at 11.15 or 11.20. To all this we heartily agree, merely premising that A, B, and C should respectively pay for their special trains, or club the cost with their friends, desiring to enjoy their society *en route*. It is not, of course, the business of a railway company to provide passengers for every train, but conveyance merely. The passengers must come or stay away, as they choose.

But without pursuing this line of thought, it is almost needless to say that the present system of railway rolling stock is designed for long, well-filled, and, therefore, heavy trains, and this merely because such trains must occasionally, although not often, be taken. The resources of a railway company must never break down, and the engine which draws its six carriages for twenty-five out of twenty-six week days in a month must be able to manage twenty or thirty at nearly the same speed on the single remaining day of the calendar. It might be supposed that two engines could be employed for the long train, or that the train might be broken in two, with an engine to each half. But this is not the custom.

Cannot frequency of trains, however, and corresponding public convenience, be attained with rolling stock especially adapted for a given service, meaning by "service" the conveyance of a definite maximum number of passengers at a given speed? If one hundred passengers are to be taken they may as well be taken in one as in three or four carriages, although it is not to be forgotten that, with three classes, the twenty-four first class, the thirty seconds, and the forty thirds may not arrive in the exact order to which the wisdom and liberal provision of the designer and carriage builder may have designed them. There may be forty firsts, twenty seconds, and no thirds; or, possibly, no firsts at all, ten seconds, and a hundred and sixty thirds. If we could but arrive at the democratic equality of the American carriages—not that any one wishes it—we might manage the whole hundred of the company within as many seats.

But, taking our ideal, if, indeed, it be not a fair average real train, we should require ten compartments, if not eleven, and, if we say ten, between 50 ft. and 55 ft. in length for the compartments alone. As compartments, filled with passengers, they would not weigh beyond 15 tons—of course, irrespective of the springs, axle guards, axles, and wheels beneath. Now, what power is requisite to draw this weight, say upon average gradients of 1 in 100 to 1 in 200? The least calculation will show the power to be so small that a "modern" locomotive looks abominably huge and heavy in comparison. Upon the double bogie plan the ten compartments may readily be comprised within a single carriage, and at one end, at least, the

carriage would be supported upon the engine (Fairlie's plan), leaving only a four wheel or six wheel bogie to support the other end, a bogie weighing, perhaps, three tons. The engine, proper, would then require to be of such power as would draw 18 tons only in addition to its own weight. Upon gradients of from 1 in 250 to 1 in 100, this weight, at 30 miles an hour, would involve a tractive resistance of but from 480 lbs. to 920 lbs. It is evident, from the very extent of these resistances, that a tank engine of ten tons' weight would be sufficiently strong to overcome them as well as its own resistance, or, say, 28 tons in all, giving an average resistance on gradients of, say, 1 in 140, amounting to less than 1,000 lbs., which, at 30 miles an hour, would correspond to 80 horse power. With a pair of 9 in. cylinders, 15 in. stroke, and four coupled 5 ft. wheels, this resistance would require a mean effective pressure of a little less than 50 lbs. per square inch upon the pistons throughout their strokes, while upon a level the necessary pressure would be less than 25 lbs., and the horse power hardly 40, equal to which a good 12 horse (nominal) portable engine is often made to work. Now, with an ordinary 22 ton engine and tender, weighing in all 36 tons—such an engine as is very commonly employed upon light trains, having, say, 14 in. cylinders, 18 in. stroke, and 5 ft. driving wheels—its own resistance at 30 miles an hour on a level is not less than 720 lbs. requiring 12 lbs. mean effective pressure per square inch upon pistons of nearly twice the area assumed for the steam carriage. The engine and tender, or even the tank engine commonly employed upon light traffic lines weighs, on the average, as much as the train drawn, often, indeed, even more.

It need hardly be said that the resistances of engines and trains have been established by numberless experiments, that the resistance due to any given weight is therefore readily calculable, that it is always in proportion to the weight, and that the cost of working, and especially wear and tear, are in proportion to the resistance. With a given line, then, power can be economized and wear and tear lessened only by keeping down the weight, and why engineers should insist as they do in keeping it up we cannot explain. With the bogie, at each end, the single long carriage can be made much lighter than shorter carriages seating the same number of passengers, each carriage having its two ends, its buffers, etc. The steam carriage we have spoken of runs upon eight wheels, with not more than 3½ or 4 tons each on even the driving wheels, whereas the ordinary "train," to accommodate the same number of passengers, would have from 22 to 26 wheels with a maximum load of at least 5 tons on each driving wheel. The long single carriage would be unquestionably the easier of motion, and it has been demonstrated beyond all question by the experiments at Hatcham that it can be safely backed at twenty miles an hour around curves of no more than 50 ft. radius.

We should be sorry to believe in the truth of the charge, so often made, that railway managers and engineers are disposed to set their faces against all improvements out of which they are likely to make nothing for themselves. But we often regret that the salaries of these officers are not more generally made partly dependent upon the economies which they may effect. As it is, the general manager in the receipt of a fixed salary of from £2,000 to £5,000 a year, and the locomotive superintendent in receipt, according to position, of from £800 to £5,000 (and there is *one* case where the latter sum is paid), do not much care to be bothered. And so shareholders lose, and those who would do them real service are, to employ a serviceable phrase, "left out in the cold." But we have hopes still left, and we must find other reasons, possibly less disinterested to the gentlemen in question, if they persist much longer in willful ignorance of what not only *may be* but actually *has been* done in the direction we have pointed out.

STIFFNESS OF THE ROPE.

Written for Van Nostrand's Magazine by Capt. A. Hill, C. E.

On bending a rope over an axle or a pulley, a certain amount of resistance is encountered. This resistance is called the stiffness of the rope. To ascertain by experiment the amount of this resistance, ropes may be bent around cylinders, which are then allowed to roll on a horizontal plane. The difference in the weights which are suspended on both rope-ends, and which produce a slow rolling motion, will, after subtracting the rolling friction, give the amount of this resistance, or determine what is called the stiffness of the rope.

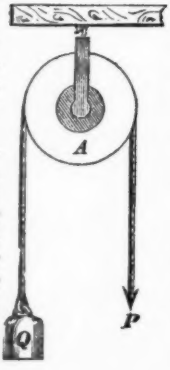
After these experiments, which, however, must not be considered final, the resistance offered through the stiffness of the rope, may be expressed by the formula

$$\delta = \frac{k\,\delta^2}{r} Q,$$

in which Q represents the tension of the rope, r the radius of the cylinder increased by one half the thicknes of the rope, δ the diameter of the rope, and k a co-efficient obtained by experience. For the metric system $k = 18$.

Tarred ropes have always a greater stiffness than untarred ones. Wet ropes, if thin, show a greater, if thick, a less flexibility, other circumstances being equal.

After the previous formula, a rope of two centimeter diameter, bent over a cylinder of four decimeter radius, stretched by a weight of 1,000 kilogrammes, shows a resistance from stiffness of about 18 kilogrammes. A similar result is obtained when a chain is wound round a cylinder. In this case, especially on winding and unwinding, the resistance is occasioned by the friction of the several links. The force necessary to overcome the resistance may approximately be called $\frac{\mu\,\delta}{r} Q$, in which δ is the diameter of the iron in the links, μ the co-efficient of sliding friction, r the radius of the cylinder increased by one half the diameter of the links, and Q the suspended weight.



Over a fixed pulley A a rope is bent, on the vertical ends of which the forces P and Q are suspended.

How great must P become in order to balance Q and all resistance? Let r be the radius of the pulley increased by one half the diameter of the rope, ς the radius of the pin, δ diameter of the rope, W the weight of the pulley, the rope and the pin, then will

$$P\,r = Q\,(r + k\,\delta^2) + \mu\,\varsigma\,(P + Q + W)$$

whence

$$P = Q\left(\frac{r + k\,\delta^2 + \mu\,\varsigma}{r - \mu\,\varsigma}\right) + W\,\frac{\mu\,\varsigma}{r - \mu\,\varsigma}.$$

Take for example, $r = 0{,}^{m}12$; $\delta = 0{,}^{m}028$; $n = 0.1$; $\varsigma = 0{,}^{m}01$; $Q = 200$ kil.; $W = 5$ kil., then will $P = 224.24$ kil.

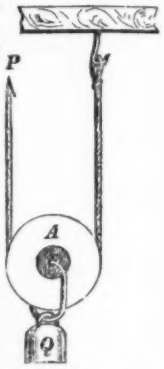
Round the movable pulley A, on the pin of which the weight Q is suspended, a rope is bent. How large must the force P become in order to balance Q and all resistance?

Using the same letters for the same quantities, the equation becomes now

$$P\,r = (r + k\,\delta^2)\,(Q + W - P) + \mu\,\varsigma\,Q,$$

whence

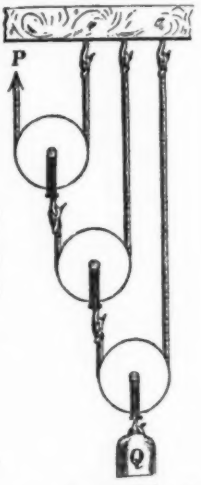
$$P = \frac{r + k\,\delta^2 + \mu\,\varsigma}{2\,r + k\,\delta^2} \times Q + \frac{r + k\,\delta^2}{2r + k\,\delta^2} W$$



And substituting the same values as above, we obtain here $P = 116.7$ kil.

To find P for a system of movable pulleys, when the directions of the rope ends are vertical, and the radii and weights of all the pulleys are equal.

Let $\psi, \psi_1, \psi_2 \ldots \psi_n$ indicate the tensions of the successive rope ends, and put



$$\frac{r + k\,\delta^2 + \mu\,\varsigma}{2\,r + k\,\delta^2} = a$$

$$\frac{r + k\,\delta^2}{2r + k\,\delta^2} = C$$

Then will

$$\psi_1 = a\,Q + C\,W$$

$$\psi_2 = a\,\psi_1 + C\,W = a^2 Q + C\,W\,(a + 1)$$

$$\psi_3 = a\,\psi_2 + C\,W = a^3 Q + C\,W\,(a^2 + a + 1)$$

$$\psi_n = a\,\psi_{n-1} + C\,W = a^n Q + C\,W\left(\frac{a^n - 1}{a - 1}\right)$$

But $P = \psi_n\left(\frac{r + k\,\delta^2 + \mu\,\varsigma}{r - \mu\,\varsigma}\right) + W\left(\frac{\mu\,\varsigma}{r - \mu\,\varsigma}\right)$ and making $\left(\frac{r - k\,\delta^2 + \mu\,\varsigma}{r - \mu\,\varsigma}\right) = a'$ and $\frac{(\mu\,\varsigma)}{r - \mu\,\varsigma} = C'$

we obtain at once

$$P = a'\left(a^n Q + C\,W\,\frac{(a^n + {}^{r}1)}{a - 1}\right\} + C'\,W.$$

Finally, to find P for a system of fixed and movable pulleys, under the supposition that the fixed and movable pulleys are corresponding in size and equal in weight.

Using the same notations as before, we have

$$(a)\; r \times_2 = (r + k\,\delta^2)\,\psi_1 + \mu\,\varsigma\,(\psi_1 + \psi_2 \ldots)$$

in which $\psi_1, \psi_2, \psi_3 \ldots \psi_n^1$ represent the

successive tensions of the rope, beginning with the fixed end. From (*a*) we obtain

$$\psi_2 = \psi_1 \frac{r + k\delta^2 + \mu\varsigma}{r - \mu\varsigma}$$

or making

$$\frac{r + k\delta^2 + \mu\varsigma}{r + \mu\varsigma} = a$$

$\psi_2 = a\,\psi_1$, and hence

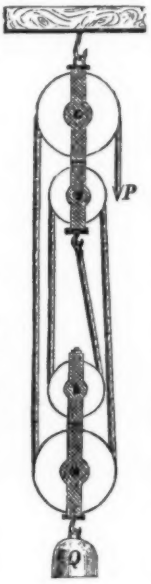
$\psi_3 = a\,\psi_2 = a^2\,\psi_1$,

$\psi_n = a\,\psi_{n-1} = a^{n-1}\,\psi_1$,

but $\psi^1 + \psi_2 + \psi_3 + \ldots$,

$\psi_n = Q + W$

in which W equals the weight of the system of movable pulleys.



Substituting in this last equation the values for ψ_2, ψ_3 . . . . ψ_n in terms of ψ_1, we obtain

$\psi_1 (1 + a + a^2 + \ldots\ldots$

$C^{n-1}) = Q + W$

or $\psi_1 = Q + W\left(\frac{a-1}{a^n-1}\right)$

but since $P = a^n\,\psi_1$. we have

$$P = \frac{a^{n+1} - a^n}{a^n - 1}(Q + W).$$

How to Build.—We read that the builders of ancient Rome were obliged to warrant their private buildings for ten years, and their public ones for fifteen. Moreover, every accident arising from bad construction during these periods *was to be made good by them or their heirs.* If they were unable to make the necessary repairs, they were whipped, shamed and banished. Some such law like this, if it could be enforced in the nineteenth century, within the bills of mortality of this great city of London, would work a salutary and lasting reform. It is not "how to build," but how not to build; consequently structures are very often, in fact are daily, being erected, whose best recommendation is that they are certain to kill off some portion of every family which may have the misfortune to live in them.

In the first stage of their existence, they effect this by dampness, want of ventilation and the absence of any proper system of drainage. In the second stage of existence of these houses, they kill off their inmates by the presence of too much ventilation. Doors, windows, and roofs exhibit the effects of employing green or unseasoned timber; aching pains begin to trouble the joints and shoulders; and, like the human body, the framing body of joinery creaks with a chronic asthma. In the house where there was insufficient ventilation first, there is any quantity of wind and weather now, for tenon and mortise part company, and paper, lath, and plaster follow suit, with a groan for the internal genii.

The third stage in the life of those model structures is this: that they suddenly drop to the earth with an epileptic spasm, without the least external warning; and in annihilating themselves they bury several families in the one general crash.

Need we add the sequel? Scarcely. We will simply note an "inquest,"—verdict, "accidental death." Not a word of censure on the "jerry builder" or sham contractor, who made a nice thing out of speculating in the blood of his fellow beings. Not a word of reproof on the man that "did not want any of your confounded architects." Not one word on the jack-of-all-trades who was surveyor, engineer, architect, and all. No, not a word. He, like other "lucky dogs," caught up the "tip" of the day, and his trade is to build to *sell*, and not to build to *last*.

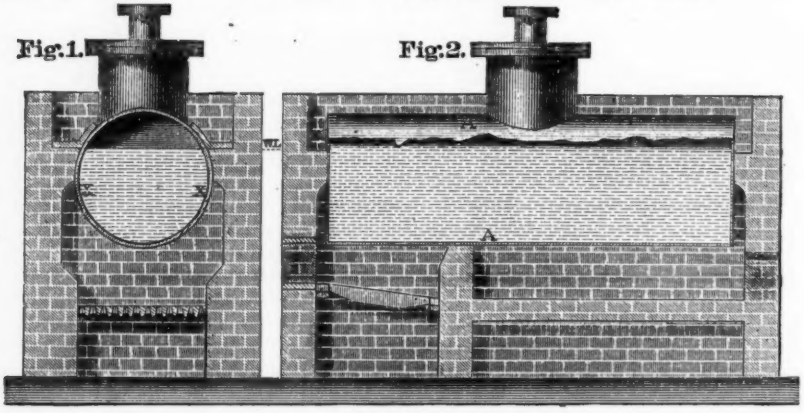
Oh, would that the old Roman law were still in force, or that a vigilance committee were embodied so that the building ghouls of London could be "whipped, shamed and banished" from the country!—*Builder*.

Engine Cranks Cast prom Steel.—Messrs. Vickers, Sons & Co., Sheffield, have turned out the second of two of the largest steel cranks ever made, and these cast direct to shape, and not as an ingot.—Its weight, as cast, was 38,500 lbs., or about 17 tons 4 cwt. Five hundred and fifty crucibles were poured, in regular order, in making it. Steel castings have shown surprising and uniform cohesive strength and toughness. They are unquestionably free from any internal flaws or defects of any kind. A cast-steel engine crank, especially of large dimensions, is more likely to be sound (apart from the greater strength of steel *per se*) than a heavy wrought-iron forging of the same shape. Even in wrought-iron forgings presenting no visible or definite flaw, sections cut out and tested have been found to bear no more than 7,000 or 8,000 lbs. per sq. in. The strength of steel, on the contrary, would not vary much from 70,000 lbs.—a strength attended with great toughness or endurance when exposed to sudden shocks.

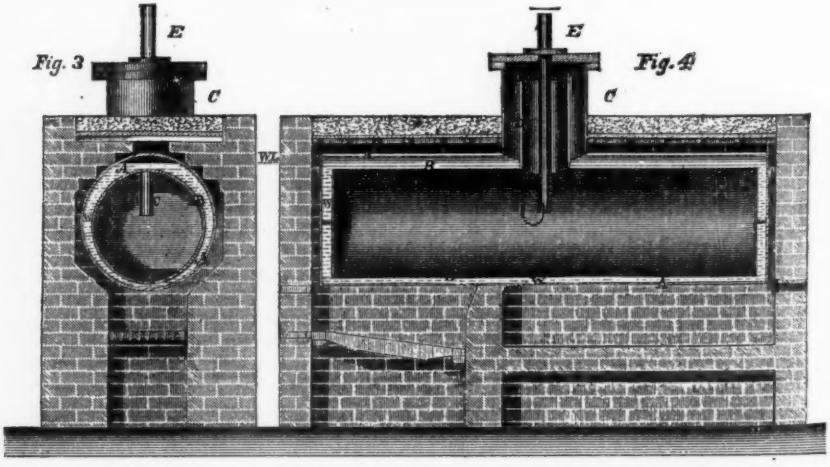
THE GERNER BOILER.

This form of steam generator having now been in actual service for a sufficient time to warrant definite conclusions, and having been subjected to a variety of tests, has developed some notable advantages in working and maintenance, and is attracting a great deal of attention among the users of steam. The accompanying engravings, prepared for this magazine from the latest working drawings adopted, illustrate the different forms of service to which the Gerner principle of construction has been applied. The description and working results are given on the authority of the "Scientific American."

The inventor of this boiler, starting with the assumption that, so far as safety alone is regarded, no form of boiler is superior to the old-fashioned cylinder, has proceeded step by step to develop its steam-producing power without relinquishing its known elements of safety. Figs. 1 and 2 show an end and side view of a plain cylinder boiler, set in brick-work, the space from X to X, around the lower section of the boiler, showing the extent of heating surface. Figs. 3 and 4 give two views of the same boiler, with its power and economy increased by the application of the Gerner Re-inforcement, an application that may be made to any plain cylinder or flue boiler.



Common Cylindrical Boiler.



The Common Cylindrical Boiler with the Gerner Reinforcement attached.

The Gerner Re-inforcement consists in placing within a cylindrical boiler another cylinder of just sufficiently smaller size to leave a space (when set a little out of center) of about 4 in. at the bottom and ends, increasing gradually to about 6 in. at the top. This cylinder, by displacing the large mass of water, as shown in Fig. 2, reduces it to a thin sheet, which fills the space between the two cylinders, and entirely surrounds the inner one; the water line being now near the top instead of the middle of the boiler. The inner cylinder is simply supported at each end by a bracket attached to the outer boiler, and is provided with a dome, open at the top, standing within the dome of the outside cylinder. The steam, as it is generated, rises, as shown by the arrows in Fig. 4, into the outer dome, and thence passes by the inner dome into the interior of the inner cylinder, which thus becomes a large steam reservoir entirely filled with dry steam, which is kept in its normal condition by the jacket of hot water which surrounds and protects it from radiation, the temperature which protects being the same that produced it. The steam-pipe E acts as a steam-trap to convey only dry steam. It will be observed that the pressure of the steam within the reservoir equalizes that of the steam in the water outside, thus obviating the necessity for "staying" and the use of heavy iron in its construction. The water being carried so high in the boiler admits of the brick-work being set off from it, and the fire thus carried entirely around it, throughout its entire length and ends, thereby

Fig. 5.

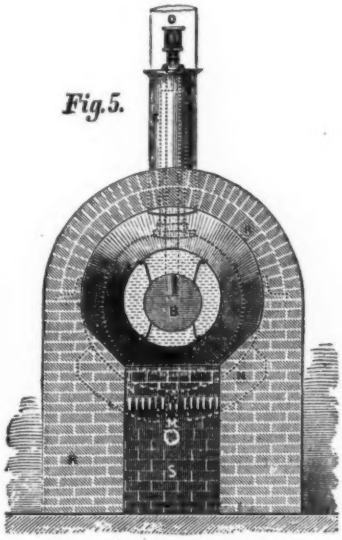
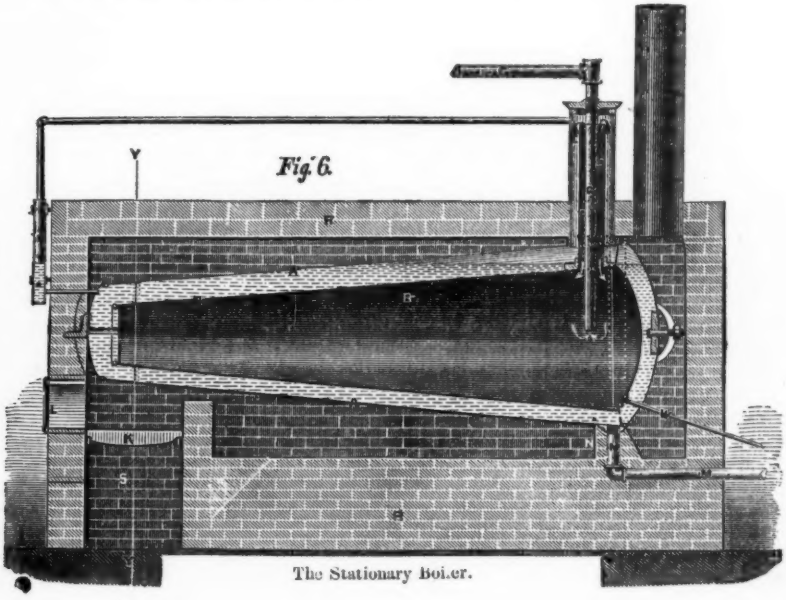


Fig. 6.



The Stationary Boiler.

doubling the extent of heating surface. The brick-work may be thrown in an arch over the boiler, or the successive layers of brick "stepped in" like a reverberatory furnace, as shown in Fig. 3. It should also be observed that the lessened volume of water materially increases the safety of the boiler. C. Wye Williams, in his able work on "Heat and Steam," page 171, asserts that "the risk of explosion is greatly increased by the increase of water in the boiler, every cubic foot of which, beyond what is absolutely necessary for the generation of steam, being an additional source of danger."

The Stationary Boiler.—Figs. 5 and 6 represent the usual form of the Gerner stationary boiler. The shell is cone-shaped, its smaller end being over the grate; the axis is set level. The flame envelopes the boiler, and its escape is checked at the top and sides by a brick partition at the rear, and its exit is through a vent underneath the larger end of the boiler into the flue and chimney. Within the shell is placed a similar cylinder of less dimensions, leaving an annular water space of about 4 in. at the bottom, and 6 in. at the top.

The angle of the heating surface, as here presented to the action of the fire, is best calculated to catch and absorb the heat, impingement being more direct and effective, while the free circulation of the water, from the position in which the conical shells retain it, is greatly promoted. This form also provides an extensive combustion chamber, wherein the gases may become thoroughly ignited, while the rapidly narrowing passage towards the flue, in both the vertical and horizontal direction, so progressively retards the gases in their passage to the outlet, that their combustion is perfected, and their heat, as far as possible, imparted to the boiler. There is no lodgment for refuse, ashes and dirt about the boiler, and all sediment within is naturally deposited at its lowest point, T, whence it is easily blown off. The advantage derived from setting the boiler without contact with the brick-work is great, for when, as is necessary with ordinary boilers, the brick-work and the boiler are brought in contact, any water from the top will settle at the point of contact, become decomposed, and very quickly weaken the boiler by oxidizing the iron. The "Society for the Prevention of Boiler Explosions," in England, report that 50 per cent of the explosions of stationary boilers are clearly traceable to this cause. Unequal expansion and contraction are also, doubtless, as much promoted in a boiler but half bricked in, as in a tubular or locomotive boiler with its varying diameters and position of shell and tubes; for the upper half, exposed to the atmosphere, while the lower part is subject to intense heat, must be unequally affected, and soon lead to the rapid destruction of the boiler.

The Portable Boiler.—This boiler, Figs. 9, 10 and 11, has the form throughout of a locomotive fire-box, with a double shell all over, and open at the back end, the space between the shells being about 3 in. at the bottom, 4 in. at the sides and front end, and 10 or 12 in. at the top. Within this fire-box shaped boiler is placed an exact counterpart of the Gerner stationary boiler. The feed-pipe to both the inner and outer boiler is shown at F F, and the connecting pipe at X. Apart from these two pipes there is no water or steam connection between the two boilers, and with these connections severed, the boilers become in fact two separate steam generators. The inner boiler is supported by a rod in its front end, resting within an expanded tube in the front of the outer boiler, and by two set screws S S, Fig. 11, which pass through lugs in the dome, on to a plate on the outside of the outer boiler. The open end of the outer boiler, after the inner boiler is placed in position, is closed by a cast-iron plate, which arrests the flames after their passage around and underneath the inner boiler, and diverts them into the uptake or chimney. A plate R is placed underneath the inner boiler near the back end, to reduce the size of the escape flue, and to compel the heat to strike the bottom of the boiler in the rear. The water-line in both boilers is the same, and the steam from both is conveyed into the steam reservoir B.

It is a well-known fact that the fire-box of a locomotive boiler is its most effective part, owing to the free development and maintenance of the flame in one mass, not divided by flues, thus illustrating the rule laid down by Sir Humphrey Davy, that "heat communicated by flame depends on its mass." This principle has been still further illustrated by the fact, that the efficiency and economy of many tubular boilers has been greatly increased by lengthening the fire-box and cutting down the length of the tubes. In view of these facts, it is claimed that the outer boiler, above described, furnishes very effective and desira-

Fig. 9

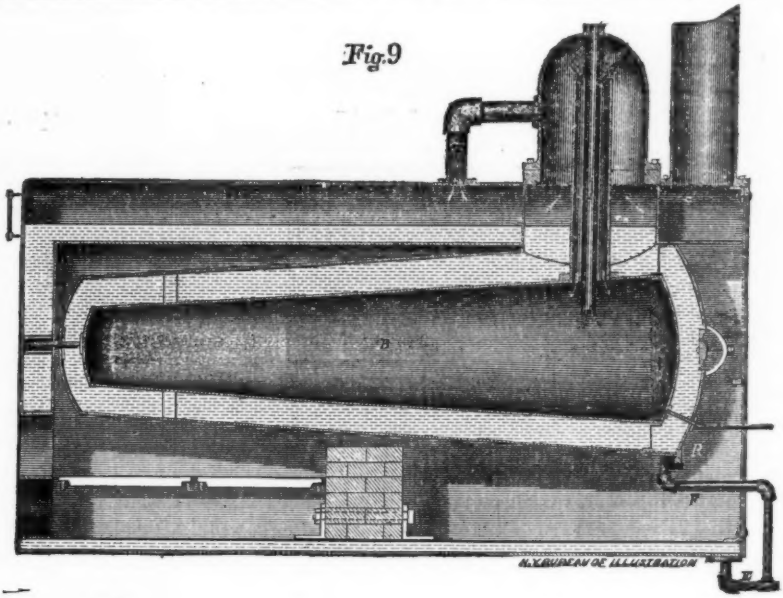


Fig. 11.

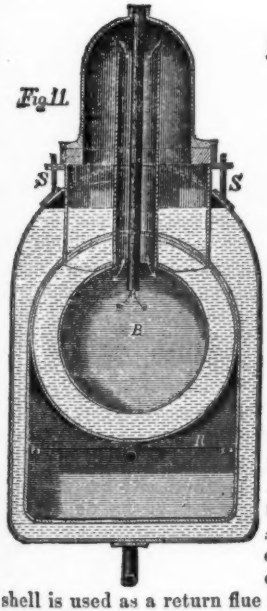
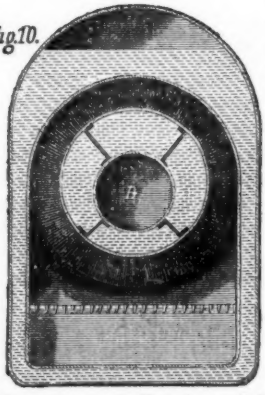


Fig. 10.



able surface for the generation of steam, without presenting any impediment for the free circulation of the water within, or lodgment of ashes or refuse without; and that the inner boiler adds the other advantages of the Gerner principle.

The Marine Boiler.—This boiler, Figs. 13 and 14, may be described as a single return conical flue boiler, forming a conical combustion chamber. Its peculiarity consists in its conical shaped flues and their annular water spaces.

The outer shell A is a plain cylinder, the inner shell B conforms to the shape of the outer shell (forming a space increasing from 4 to 6 in. between the two), to a height somewhat above the center of the boiler, from thence it turns inwardly, and dropping down connects with the outer shell of the double-shelled conical flue. This doubled shelled conical flue traverses the length of the boiler, its smaller end being over the grate bars, and the interior of its inner shell is used as a return flue to the uptake at the front of the boiler, instead of an interior steam receiver. The water space of from 4 to 6 in. between the shells of the outer boiler connects at the ends and on top with those of the doubled shelled flue, which are of the same width, and there is a further connection between the water bottom near its back end, and the water space around the conical flue at its largest end, by the

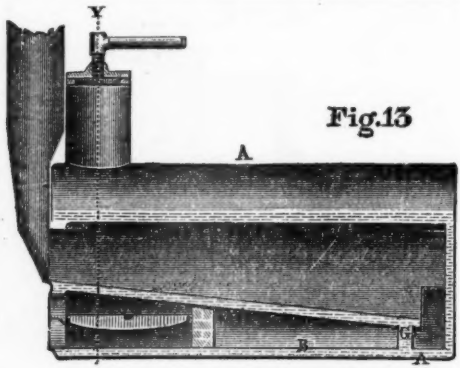


Fig.13

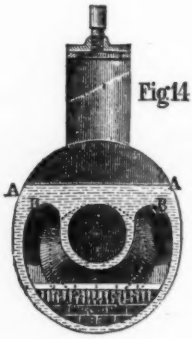


Fig14

The Gerner Marine Boiler.

circulating pipe G. The fire-box or furnace portion of the boiler, it will be seen, is very extensive, wherein the flame is maintained in an undivided mass, and the heating surface on all sides presented to its action in a manner best calculated to obtain great efficiency. The gradually narrowing passage towards the opening into the return flue retards the gases of combustion until the greater amount of direct heat is utilized, and after entering the flue, they are still further retarded in their escape to the chimney by the tapering form of the flue, and their entire available heat imparted, as far as possible, to the plates containing thin sheets of water.

Rate of Evaporation.—The authority we have referred to gives, "from actual knowledge," the results of a trial of a Gerner stationary boiler, by the means adopted in the U. S. Navy experiments. The boiler is 10 ft. long, 2 ft. front, and 3 ft. rear diameter, with a grate surface of $4\frac{44}{100}$ sq. ft. The experiments show that the boiler is producing 500 lbs. of dry steam per hour for every 50 lbs. of coal consumed, after setting aside the fraction .65 of a lb. over 10 lbs. of steam produced by the consumption of a pound of anthracite. This margin of 6.5 per cent of the total production will cover many of the defects of unskillful firing. Assuming, then, that in practice the boiler will evaporate 500 lbs. of water per hour with a consumption of 50 lbs. of coal, and allowing 33 lbs. of water to be the fair standard of a horse-power, this boiler is capable of supplying 15 horse-power. The total heating surface being $83\frac{30}{100}$ sq. ft., and the results obtained being over 15 horse-power, shows $5\frac{1}{2}$ sq. ft. in these boilers to be sufficient to produce a horse-power, and illustrates the efficiency of the heating surface.

The test of a marine boiler (*i. e.*, built upon the same plan as one intended for a steam-vessel) now in operation at the New York and Erie R. R. General offices (Grand Opera House), New York, is given by the same authority. The boiler is 16 ft. long, $6\frac{1}{2}$ ft. in diameter, and has produced, according to the testimony of J. W. Brooks, Superintendent of Motive Power N. Y. and E. R. R., 110 horse-power, 3,300 lbs. water evaporated per hour, with an economical result of over 12 lbs. of water to 1 lb. of coal. The entire heating surface being but 400 sq. ft., gives less than 4 sq. ft. to a horse-power.

This result may be better appreciated by taking in comparison a tubular boiler, say $23\frac{1}{2}$ ft. long by 6 ft. in diameter, containing with its tubes a total heating surface of 1,139 sq. ft. Such a boiler, by allowing the ordinary standard of 15 sq. ft. to a horse-power, would be estimated at 75 horse-power, and its steady economical result could hardly be relied upon at over $6\frac{1}{2}$ to 7 pounds water to 1 of coal, with no assurance whatever of the dryness of its steam.

There is no doubt as to the comparative inefficiency of heating surfaces made up of small flues. Various authorities have been quoted in this connection, among others Armstrong (revised by Bourne), who says that "the present construction of the multitubular boiler, as it is called, may be truly stated as a disgrace to the science of this age of progress." C. Wye Williams says: "Heat, communicated by flame, must depend on its mass;" also that "the tubular system is chemically, mechanically, and

practically a destroyer of ignition and the sustained existence of flame." Again he says: "The result of the adoption of the multitubular system has been a less perfect combustion, a larger development of opaque smoke, a greater waste of fuel and heat, and a more dangerous application of it."

Various recent experiments within our own knowledge appear to confirm these views. In one small locomotive boiler, for instance, the flues were almost entirely abandoned, and the fire-box was extended nearly the whole length of the boiler with good results. Exact experiments, however, have not been made in this case. The following considerations, at least, will be admitted by all experts: fire-box surfaces are vastly more efficient than flue surfaces. In the multitubular boiler, the flame entering the small tubes is extinguished, combustion of the gases ceases, and a very large proportion of the otherwise available heat pases off in smoke and unconsumed gases, and is lost; free circulation of water is obviously impeded by the multitude of small tubes, and the small inetrstices between them provide a very ready means for the retention of impurities in the water, and consequent incrustation; and, finally, the mechanical difficulty of keeping the tubes tight, in their varing expansions and contractions, is an expensive and dangerous experience to almost all who have used them.

The claim of *economy* made for the Gerner boiler appears, therefore, to be well founded in theory as well as in practice. The *safety* of the cylindrical form, as compared with flat sides, is obvious. The other advantages claimed have been referred to in detail, with the descriptions of the various forms of the boiler. We may add that these boilers are guaranteed for a rate of vaporization in accordance with the results of the experiments above stated.

Safety Car Trucks.—Mr. Morris, of the Housatonic Railway, has devised an improvement for relieving the effects of a broken car wheel or rail. He attaches to the truck frame, just inside of the wheels, two stout sled runners, made of heavy plank shod with metal or entirely of metal. In case of running off the track, these runners receive at once the weight of the car, and prevent all but a slight sinking of the wheels. They act as brakes to check the speed and also prevent lateral motion of the car.

COMBUSTION UNDER PRESSURE.

From "Engineering."

We propose to explain briefly what we believe to be the theory of Mr. Bessemer's system of high-pressure furnaces, and show why the fact of the combustion taking place under pressure should cause the intensity of the heat produced to be increased. Fifteen or sixteen years ago, before the question had been settled by the experiments of Regnault, it was considered by many investigators, who either disbelieved or did not perfectly comprehend the dynamical theory of heat, that the specific heat of air and other gases was decreased by an increase in the pressure under which they were confined. We should not have referred to this fact here, but that some recent writers, arguing falsely from the experiments made by Clements and Desormes early in the present century, have endorsed this opinion, and stated that the specific heat of gases decreased as the square root of the pressure to which they were exposed. According to these theorists, the increase of temperature obtained by Mr. Bessemer's high pressure system would be simply due to the fact that the gases generated by combustion being under pressure, had a less specific heat than those escaping from an ordinary furnace fire, and that consequently a given quantity of heat was capable of raising them to a higher temperature than could be obtained under ordinary circumstances. The admirable experiments of Regnault, however, described by him in the "Comptes Rendus" for 1853, conclusively proved that the specific heat of air was sensibly constant at all pressures and temperatures at which it was tested, and the explanation we have just mentioned is therefore an untenable one. We shall now proceed to state what we believe to be the true explanation of the results obtained by Mr. Bessemer, these results being, we consider, fully accounted for by the dynamical theory of heat.

It was long ago shown by Poisson and Laplace that the quantity of heat required to raise the temperature of a given weight of any gas, a certain number of degrees, is less if that gas was maintained at a constant volume, than if it is allowed to expand freely during the heating process. In other words, the specific heat of a gas maintained at a constant volume is less than that of the same gas maintained at a constant pressure, the difference in the two specific heats under

the two circumstances being due to the heat absorbed in performing the work of expansion. In the case of air the two specific heats have been ascertained to be .169 and .238 respectively (that of water being denoted by 1), and it thus appears that a pound of air in expanding to the extent due to a rise of temperature of 1°, absorbs, or renders latent, .238—.169 = .069 of a unit of heat. It is to this fact that the heating of air which takes place under compression is due, for when a quantity of air is reduced in bulk, the heat which had been previously employed in maintaining it in an expanded state becomes re-converted into sensible heat, and the temperature of the air is raised accordingly. It will thus be seen that the compression of the air does not increase the quantity of heat contained in it, but merely renders sensible a portion which was previously latent, and it follows, therefore, that a certain weight of air or gases containing a given quantity of heat will have a higher temperature if compressed than if maintained at ordinary atmospheric pressure.

In Mr. Bessemer's high-pressure furnaces the gaseous products of combustion are, it is true, not allowed to expand and then heated by compression, but they are prevented from expanding as they would do in an ordinary furnace, and, as far as the results go, the effect is the same. In other words, in a high-pressure furnace working at a pressure of, say, two atmospheres, the temperature of the gaseous products of combustion is the same as if they had been allowed to expand under ordinary atmospheric pressure, and then suddenly compressed until the pressure became doubled. Now it can be shown by reasoning founded on the data we have given, that what is known as the *absolute* temperature — or the temperature in degrees Fahrenheit + 461.2°—of any given quantity of air will, if that air be compressed, vary as the .29th power* of its pressure above a vacuum; or, in other words, if T_1 = absolute temperature of a certain quantity of air under a pressure P_1, its temperature, T_2, under another pressure, P_2, will equal $T_1 \times \left(\frac{P_2}{P_1}\right)^{.29}$. If now we assume, as we probably may do without any sensible error, that this formula for air is applicable to the gaseous products of combustion obtained in a high-pressure furnace, we shall be in a position to calculate the increase of temperature due to the adoption of the high-pressure system in any particular case. Perhaps an example or two may render this clearer.

Let us suppose, for instance, the case of a furnace in which the proportions of carbonic acid and carbonic oxide produced by the combustion of the fuel are as one to four, and let this furnace be worked, in the first instance, under ordinary atmospheric pressure. Now, we showed in the early part of the article, in our number for the 17th ult., to which we have already referred, that when carbon is supplied with just sufficient air for combustion, and is burnt into carbonic acid, the highest temperature theoretically obtainable is about 4,500°, while if it is burnt into carbonic oxide, the temperature will be about 2,250° only. In the case we are now considering, therefore, supposing that there is no loss of heat from radiation or the admission of excess of air, etc., the most intense heat attainable will be $\frac{(2{,}250 \times 4) + 4{,}500}{5} = 2{,}700°$ above the temperature of the air and fuel introduced into the furnace. If, now, the temperature at which the materials are introduced be taken as 60°, the temperature of the products of combustion under the above circumstances will be 2,760°, and their *absolute* temperature 2,760 + 461.2 = 3,221.2°. Let us next suppose that the furnace is worked at a pressure of 15 lbs. per sq. in. above the atmosphere, or, say, at a pressure of two atmospheres, the products of combustion being the same as before. In this case the *absolute* temperature of the products instead of being 3,221.2°, will be $3{,}221.2 \times 2^{.29} = 3{,}221.2 \times 1.222 = 3{,}936.3°$, and their temperature expressed in the ordinary way will be 3,936.3—461.2 = 3,475.1, or, say, 3,475°, being a temperature 715° higher than that obtained in a furnace worked at atmospheric pressure. In the same way we should expect to find that if the pressure under which the furnace is worked is increased to three atmospheres, the temperature of the products of combustion will rise to $(3{,}221.2 \times 3^{.29}) - 461.2 = (3{,}221 \times 1.375) - 461.2 = 3{,}967.9°$, or, say, 3,968°, a temperature more than 1,200° in excess of that obtainable under ordinary circumstances.

It will, of course, be understood that the temperatures above given are merely rela-

* The .29th power of any number may be readily obtained by the use of a table of logarithms.

tive, being illustrative of the effects due to the high-pressure system of working as compared with what we may call, for distinction, the ordinary low-pressure system. In practice the actual temperatures obtained will depend not only upon the pressure used, but also, for the reasons we have already explained in our former article, upon the completeness of the conversion of the carbon of the fuel into carbonic acid, and upon the manner in which the supply of air is adjusted, as well as upon the means adopted to prevent loss of heat. Mr. Bessemer is, we understand, about to try a series of experiments on a furnace worked at various pressures, and we look forward with much interest to the results of these experiments, which we shall be glad to know agree with the theory we have advanced.

TRANSMISSION OF POWER BY WIRE ROPES.—There are, at Moulins Galant, near Corbeil, 22 miles south of Paris, some important paper mills belonging to MM. Darblay and Company. One of these mills is worked by an hydraulic wheel of about 30 horse-power. But the power of this wheel not being sufficient all the year round, it was necessary to provide a supplementary power, which has been obtained from another fall on the same river, 770 yards up the valley. This fall, of about 40 or 45 horse-power, was formerly, and is even now, used for working a flour mill, which has been taken on lease by M. Darblay. The connection between the flour mill and the paper mill has been made with a telodynamic* wire. This system of transmission consists of an iron endless wire supported by pulleys, and running at a very great speed. It is thus possible to transmit a large power through a very thin wire, and this system is now extensively used in France, especially in the eastern districts. The Moulins Galant wire is worth notice, because, besides its great length, the axles of the driving and driven pulleys are neither parallel nor situated at the same level. The angle between these axles is 8 deg. 10 min., and the driving axle is 14 ft. 1 in. above the other; both are, of course, horizontal. The wire has been arranged in a polygonal line, and at each summit of this polygonal line there are two pulleys, bearing the driving and the driven wire. It was necessary to give to the axles of these pulleys such an inclination that the plan of the pulley should include the tangents to the two adjoining curves of the wire by each side of the pulley. The shape of these curves, and the inclination of their tangent, had accordingly to be calculated with the greatest care; and the pulleys had afterwards to be accurately arranged in the calculated situation. Any mistake in these calculations would produce a great waste of power, and sometimes would enable the wire to get out of the grooves of the pulleys. All this plant has been successfully arranged by MM. Callon and Vigreux, civil engineers, and it has worked quite well for nearly eight months. The diameter of the rope is $\frac{1}{2}$ in., it weighs 9 lbs. per yard, and it consists of 48 iron wires $\frac{1}{24}$ in. diameter, and of a central hemp strand of about $\frac{1}{4}$ in. diameter. The speed of the rope is 61 ft. 9 in. per minute, and the calculated strain is 666 lbs. on the driving, and 313 lbs. on the driven wire. The diameter of the driving and driven pulleys is 8 ft., and they have an angular speed of 150 revolutions per minute. The hydraulic wheel running only $3\frac{1}{2}$ revolutions per minute, the proper speed is given to the driving pulley through two intermediate wrought-iron shafts, supplied with cast-iron spur-wheels. The wire is supported by seven intermediate pulleys, 6 ft. 6 in. diameter, and there is an average span of 246 ft. between these pulleys. There are some masonry piers, 10 ft. to 20 ft. high, carrying these pulleys, and supplied with wrought-iron ladders for oiling the journals. The average deflection of the wire between the pulleys is 10 ft. for the driven and 5 ft. for the driving wire. This latter runs very near the ground in some places through the meadows. The inclination on the horizontal of the shafts of the pulleys is 4 deg. 8 min. for the driven, and 8 deg. 28 min. for the driving wire. It is also necessary to calculate very accurately the total length of the rope; upon the length depends the tension; with a too great length the wire could be allowed to slip in spite of the leather lining of the grooves of the pulleys; with too short a wire the friction would be uselessly increased; in both cases the wire would be liable to fall down the pulleys. This dangerous accident happened once at Moulins Galant, the wire being pulled by a hay cart crossing under it, but nobody was injured. The calculated slack of the wire is about 20 ft., and this length has been ascertained to answer quite well. There is

* From the Greek τηλε far, and δυναμις power.

a telegraphic connection between the two mills in order to stop the wheel when there is some accident to the paper mill. The flour mill is of course kept at work when there is in the river a sufficient flow of water, and when all the requirements of the paper mill are performed. The waste of power by friction is about one-sixth of the total power. The wire is without any connection with the paper engine of the paper mill, which is worked by a small steam engine.

It must be remembered that when such ropes are worked in connection with a steam engine, this latter wants a very powerful quickly acting governor, in order to prevent the overrunning of the engine, should the wire suddenly break down. Such an accident happened, some years ago, in a cotton-spinning works in Alsace, and a large steam engine was entirely destroyed.—*Cor. The Engineer.*

COIGNET'S ARTIFICIAL STONE.

From "Engineering."

For about twelve years the "Béton aggloméré" of M. F. Coignet has been employed in France, at first sparingly, and with hesitation, but of late so largely and with so much confidence, that many of the large works in and near Paris have been constructed for the most part, or entirely, with this material.

So early as 1850, M. Coignet had experimented further than his predecessors Fleuret (1800) and Lebrun (1829), but the conglomerate he then produced was unsatisfactory. In the commencement he employed a crude mixture of coal cinder with lime, and subsequently he substituted sand for the former ingredient, and mixed it with powdered lime, moistening both together instead of wetting the lime as he at first done. The second process to which he arrived, after modification and a long series of experiments with materials from different districts, and under varying circumstances, to ascertain the best proportions, is the system which has now grown into such a vast industry, and which bears his name.

The béton Coignet is a mixture of a large proportion of sand with a small proportion of lime, to which is added a percentage of cement varying with the amount of hardness or the rapidity of setting required. Only a very small quantity of water is employed to moisten the lime and sand. Thus tempered the mass is reduced, in a grinding mill, to a stiff paste, and is introduced into moulds of any desired form, being then subjected to the action of repeated and heavy blows. By this means it is thoroughly agglomerated, and the mould being almost immediately removed, the béton, shaped to the desired figure, shortly becomes set, and acquires the hardness of stone.

The material thus mixed and compressed under the hammer, when placed in the mould, receives a weight, strength, and density which renders it a thoroughly trust-worthy building material. On the average 1.31 bushels of component parts, sand, lime and cement, make a cubic foot of béton which will weigh about 140 lbs., and offer a resistance of some $2\frac{1}{2}$ tons per square inch, while ordinary mortar, formed of the same constituents, will exhibit very insignificant powers of resistance. The difference arises principally from the difference in manipulation; in mixing mortar an excess of water is always used, which is distributed throughout the mass, and separates the particles of lime and sand, retarding the setting, and when after a time the water evaporates, it leaves the mortar more or less porous.

Theoretically, the Coignet process fills all the necessary conditions, and produces a perfect béton, the sand and lime being moistened with a minimum of water, and mingled as intimately as possible. Besides the thorough cohesion of the particles induced by the mixing and compression, the small quantity of water used makes the setting more rapid and more uniform.

In all cases the lime used should be hydraulic, in fine powder, and well screened, to free it from lumps; for if there are any lumps admitted into the béton they swell when the mixture is diluted, and weaken the material.

The cements used are always, if possible, heavy and slow setting. The quantity used is proportioned to the rapidity of setting required, and the hardness of stone which it is sought to obtain. For the third ingredient, river sand, mingled with small pebbles, is the best. If the pebbles are large, the concrete produced is rough and unsightly; if it is too fine, it retards the setting, and reduces the hardness. Pit sand will make very good work, but to produce a stone so good as that formed on a base of river sand, the proportions of cement and lime have to be increased. Very fine sands like those of the Landes, require very careful mixing and a

prolonged compression in the mould to produce a first-class béton.

The ingredients are measured into a mixing mill in barrows, and during the process small quantities of water are gradually added as the mixing proceeds, until the béton becomes in the necessary condition; the more completely this part of the work is done the more rapid will be the setting, and the harder will the stone become.

The ordinary form of grinding mill employed consists of an iron cistern, the bottom of which is perforated, and in the center of which revolves a vertical shaft, armed with a number of helical knives, and carrying beneath it a cycloidal arm, which in each revolution discharges a part of the paste. A penstock covering the outlet regulates the discharge of the béton. The material thus obtained from the mill is in a firm but plastic state, and it is thrown into a mould, in thin layers, and each layer, as it is laid in, is beaten and compressed by the regular and even blow of a sixteen pound hammer. In order to secure a perfect adhesion and union of the different layers of material, especially when fine sand is used, it is generally the custom to cross cut the surface of the layer in order that the superincumbent thickness may be thoroughly united to it.

There are two kinds of moulding to which the Coignet béton is applied, the first being used when the material is employed *en masse* in place, the second when it is moulded in blocks to be subsequently employed. The moulds which are intended to be used in place are composed of close boarding kept in place by means of cross bracing. This mould carries the ornaments which are destined to appear upon the face of the structure after completion. In the second class of work all kinds of ornament can be produced from cornices to statuary.

Of late years the application of the Coignet béton has been equally extensive and varied. In Egypt, where it has been employed on a vast scale, light-houses have been reared out of the almost impalpable sands of the Isthmus of Suez. In Paris, some 40 miles of sewers have been constructed of the same material; and arches of the basement buildings of the Exhibition of 1867, saw mills at Aubervilliers, the numerous cellers of many private houses, entire buildings of five and six stories in height, railway bridges at Sainte Colombe, on the Paris, Lyons, and Mediterranean line, a church at Vérinet, and above all the large works connected with the new Paris water supply, and some examples of which we illustrate on another page.

The exact proportion of materials employed on works of different classes, and with sand and lime produced from different districts, will be interesting. Thus the work about the Exhibition of 1867 was formed of a mixture by bulk of 5 of sand, 1 of lime, and $\frac{1}{4}$ of cement. The same proportion holds good for the sewers, and the rapidity of setting is as great, that the centering can be struck within ten hours after the béton is got in place, and the sewers can be put into service in four or five days after their completion. Arches, of which the rise is one-tenth of the span, are generally made with a mixture of 5 of sand to 1 of lime, and $\frac{1}{2}$ of cement in bulk.

The church at Vérinet is one of the most interesting of the monolithic structures, and was constructed of sand from pits at Vérinet. The mixture was 5 of sand to 1 of lime and $\frac{1}{4}$ of cement. In the saw mill of Aubervilliers, the arches are 27 ft. 10 in. in span and $13\frac{3}{4}$ ft. thick at the crown, the proportions are also 5, and 1, and $\frac{1}{2}$ of cement. One of the most generally useful applications of this material is in the construction of the basements of houses. In the ordinary form of construction, stone piers, supporting rubble masonary arches, are employed, involving numberless joints, and causing an absence of perfect uniformity. From this cause numerous settlements ensue, which are avoided by the use of the homogeneous béton; for the whole sub-structure can be made in one single block, over which the superincumbent load is equally distributed, and a uniform pressure upon the foundation is obtained. One house, in the Rue de Miromesnil, is constructed entirely of béton, and it contains two staircases, the one formed in the usual way, with a number of moulded blocks, the other a spiral staircase, from basement to garret—a monolith.

Aqueducts are now being constructed from this stone upon the works for the supply of Paris with water from the Vanne. Already a part of the city draws its supply from the Dhuys, but the second portion of the system is not yet complete. The distance of Paris from the source of the Vanne is more than 94 miles, and in its course to the city the line has to traverse a series of valleys and ravines, to cross rivers, roads and railways, and the numerous requirements of the works have involved the formation of extensive

bridges, aqueducts, syphons, and tunnels. An immense reservoir will be completed close to the park of Montsouris, and a long aqueduct upon arches will be made almost close to the old Roman aqueduct of Arcueil. But the heaviest works upon the undertaking are those crossing the valley of Fontainebleau for a distance of more than twenty-five miles between the river Loing and the river Essones. This length almost entirely, without building materials, would have involved very costly works if masonry had been employed, and the engineer-in-chief, M. Belgrand, has therefore availed himself of the Coignet process, and utilizing the vast masses of sand that lay ready to his hand, has formed the work of béton. Not only have the aqueducts been constructed of this material, but the tunnels also to the extent of several miles, about 6 ft. 6 in. in diameter and 8⅝ in. thick, and these were all formed with the same success that has attended the application of the system to the sewers of Paris, the centres having been withdrawn almost immediately after the béton had been rammed into place. The aqueducts crossing the valley are supported upon arches, extremely light, and rising to a maximum height of 50 ft. from the ground. The openings are about 42 ft. 6 in., and the thickness at the crown 15¾ in. The success which attended the application of this material in the construction of the narrow openings supporting the aqueduct, induced the engineer to extend its use to those wider arches spanning rivers, roads, and railways, and, a series of experiments having proved highly successful, monolithic structures, of 98 ft. 6 in. and 115 ft. 9 in. openings, and with one-sixth rise, were rapidly formed.

It will thus be seen that while we have refrained from experimenting (with one exception) in this method of construction, French engineers have advanced to recognize its value, and to employ it largely for a variety of work, having tested its reliability by a series of exhaustive trials. The single exception to which we refer is the concrete bridge constructed by Mr. Fowler across the Metropolitan Railway at Kensington, but even that experiment was scarcely analogous, for the material employed was simyly concrete, mixed with cement it is true, but mixed in the ordinary way, and thrown into the mould instead of being carefully set in the layers and well combined, as in the Coignet process. But the extensive adoption of concrete structures in France will probably be followed by an equally extended adoption of the system here.

BLAST-FURNACE BLOWING-ENGINES.

Translated from a paper read by Mr. SCHMAHEL, before the Upper Silesian Society of Engineers.

The Upper Silesian Society of Engineers had, in a former meeting, proposed the following questions:

Which blowing-engines are preferable, those with upright, or those with horizontal cylinders? and what are the reasons why the one or the other of these constructions is preferable? Is it advantageous to use two or more small blowing-engines in the place of a single large one?

These questions may be answered in the following manner: Horizontal blowing-engines are mostly high-pressure engines. They are not expensive, easily accessible, simple in their arrangement, and can be safely founded on almost any kind of ground. The clearance in the air-cylinders is very small. On the other hand they do not allow of a very long stroke; their piston-rods are liable to be bent, and the pistons as well as the piston-rods are worn-out unevenly, thereby causing loses of blast from leakage. They require a large surface of ground, and use a considerable quantity of lubricating materials.

Vertical blowing-engines may be constructed with beam and fly-wheel, or direct acting without fly-wheel. The former are preferable.

When compared to the horizontal engines, the vertical engines with fly-wheel have the following advantages:

1. They require less room.

2. They can be constructed with a longer stroke, which tends to diminish the loss of blast.

3. The wear of the pistons, cylinders, and stuffing-boxes is smaller.

4. The piston-rods can be guided in a more perfect manner, and thus be prevented from bending.

These engines are, however, much more expensive than those with horizontal cylinders, because they have to have a beam, and a greater number and more complicated connecting parts. They also require stronger foundations for the cylinders as well as for the stands which support the beam.

Wherever the cost was considered an important point, and where sufficient room was available, the horizontal engines have for-

merly been generally preferred. Of late, however, new blowing-engines for blast-furnaces are mostly constructed with beam, fly-wheel and upright cylinders. Vertical and direct acting blowing-engines, without fly-wheel, do not work economically when two or more such engines have to work together, as is mostly the case. For it is then to be feared that from an accidental stoppage of one of them, the pressure of the blast on the pistons of the others would be so suddenly diminished that too violent a motion might take place which would produce the breakage of the cylinder-covers, of the pistons, of the piston-rods, of the counter-balance, or of other parts of the mechanism. To prevent such accidents the cylinders must be made longer than the stroke. This causes a considerable waste in clearances, loss of blast, and a diminution of the working effect of the engine.

I had, recently, the opportunity of inspecting a great number of blowing-engines at different German iron works.

The horizontal engines I saw had blowing cylinders of 5 to 8 ft. in diameter, and 4 to 8 ft. stroke, working at a speed of 72 to 150 ft. per minute. On all these engines, with but a few exceptions, I noticed the bending of the piston-rods. Amongst the larger engines of modern construction, which I inspected, but two were free from this defect. They had hollow cast-iron piston-rods of 9 to 10 in. diameter, resting on slides 15 in. wide and 18 in. long. The pistons were made of iron-plate. The engines made 10 to 12 revolutions per minute, which number could however be increased to 20 without any trouble or danger.

A wear of the lower part of the piston-rods was not perceptible, owing to the large surface of the slides. All the vertical engines I met with were beam-engines with fly-wheel. The smallest cylinder of this kind of engines had $5\frac{1}{2}$, the largest 10 ft. diameter. The shortest stroke was $7\frac{3}{4}$, the longest stroke 9 ft. The speed varied from 144 to 288 ft. per minute. It is seen from these numbers, when compared with those mentioned before, that the vertical beam-engines can be built of larger size and more powerful and effective than those with horizontal cylinders.

As to the question whether two or more smaller engines are preferable to a single large one, it may be said that smaller engines are preferable when more than one blast-furnace has to be worked. The running expenses are more considerable, it is true. But the losses of time and work, caused by stoppage for repairs of the engine, will amount to a much higher sum, when two or more blast-furnaces are dependent on a single blowing-engine. S.

IRON AND STEEL NOTES.

Fettling or Lining Puddling Furnaces.—In the ordinary method of fettling or lining the beds and sides of puddling furnaces oxide of iron or a compound consisting mainly of oxide of iron is employed for that purpose. An invention patented by Mr. W. M. Williams, of Sheffield, consists in lining puddling furnaces with crude or prepared oxide of manganese or manganese ore, either as the chief ingredient of the fettling or as an addition to the oxide of iron or other material, which is employed. In using crude or native oxide of manganese or manganese ore without admixture with other solid, an ore is used which when pulverized and moistened will form a plastic or pasty mass, and which when heated will harden and adhere firmly to the sides and bottom of the puddling furnace. For this purpose the cheap oxides containing a considerable proportion of iron are best suited, provided they do not also contain other impurities, such as sulphur and phosphorus which would injure the iron in the furnace. When an ore or prepared oxide is used which does not harden sufficiently, after being rendered plastic by water alone, it is mixed with a sufficient quantity of finely powdered and moistened hematite or other suitable material to give it the property of hardening and adhering when heated in the furnace.

The proportions in which oxide of manganese and oxide of iron should be mixed in order to make the fettling according to this invention, vary with the nature of the cast or pig iron to be puddled. With pig iron of ordinary quality about half a hundred weight of oxide of manganese mixed with the requisite quantity of oxide of iron for the fettling of the furnace is sufficient for a charge of four to five hundred weight of pig iron. When the pig iron itself is rich in manganese a less proportion is necessary in the fettling. When the pig iron contains a large quantity of silicon and little manganese, more oxid of manganese is required in the fettling than is required with pig iron containing much oxide of manganese and little silicon. Where practicable, the inventor prefers to introduce the pig iron into the puddling furnace in a melted state; when this is done and the fettling containing oxide of manganese is laid on the bottom and lower part of the sides of the furnace, the charge gets the full benefit of the evolution of oxygen, which takes place when the oxide of manganese is heated. By the use of oxide of manganese, as described, the puddling process is expedited, and the quality of the iron or steel produced is improved. The heated iron or steel during the puddling process decomposes the oxide of manganese, causing an evolution of oxygen, which rising through the molten iron or steel rapidly oxidizes the oxidizable materials contained in the metal. A portion of the reduced manganese enters into alloy with the iron or steel and effects

the improvement in the quality of the metal which is well known to result from the use of manganese in the manufacture of iron or steel.

When oxide of manganese is mixed directly with the charge for fluxing, as has been proposed, a portion is liable to become mechanically distributed through the mass of iron ot steel in the state of an infusible powder, consisting of manganese in a low state of oxidation, and injures the mechanical properties of the metal. But when oxide of manganese is used in the fettling of the puddling furnace, according to this invention, it is gradually decomposed as the carbon and silicon of the pig iron or steel are presented to it by the stirring of the puddler, and the manganese enters the charge in a fused state either as reduced metal or as silicate.

Very little of the manganese which enters the iron or steel during the puddling process remains in the finished metal, most of the manganese separating during the finishing of the metal in the form of silicate of manganese, carrying with it other impurities, such as phosphorus and sulphur. The silicate of manganese separates from the metal more readily than silicate of iron, and is found in considerable quantity in the cinder and hammer slag. The cinder and hammer slag are therefore more valuable than ordinary cinder or hammer slag for the making of cinder iron in consequence of their richness in manganese. Although the fluxing property of oxide of manganese, either alone or mixed with oxide of iron, renders the addition of any other material to the fettling unnecessary when pig iron or steel of the ordinary qualities are puddled, yet when pig iron or steel of such quality as renders the use of alkaline fluxes desirable is about to be puddled, common salt or carbonate or nitrate of soda may be added to the oxide of manganese. A quantity of the soda salt equal to about one-fourth the weight of the oxide of manganese is generally sufficient.—*Mechanics Magazine.*

MONS. C. SCHINZ ON MESSRS. PONSARD AND BOYENVAL'S IMPROVEMENTS IN THE MANUFACTURE OF IRON.—To aim at obtaining wrought iron directly from the ores appears to be, at first sight, the most legitimate course which the inventions on the subject of iron production could take. Yet, as a matter of experience, it is plain that unless we have to deal with exceptionally rich ores, the proceeding is far from being an economical one. This becomes more apparent when we take into consideration the measures which from time to time, and up to the present day, have been adopted or proposed in carrying out this scheme. Neither Clay, in 1837, nor his successors, Reuton, Chanot, Yates, Gurit, Rager, Siemens, and recently Ponsard and F. F. Boyenval, have succeeded in solving the problem satisfactorily. With or without the use of the blast-furnace, the oxide or peroxide of iron has first to be reduced in the ores. We have on a former occasion given a lengthy description of M. Schinz's labors on the subject of blast furnaces, and must refer our readers to those columns for the better understanding of M. Schinz's position regarding the subject before us. M. Ponsard himself has lately ("Comptes Rendus," p. 177) laid his views before the Academy at Paris. He starts from the fact that the fuel used in the blast-furnace is excessive, and far beyond what is required "theoretically" for the reduction of the ores, the carbonizing of the iron, and the smelting of the pile. He proposes a separation of the chemically acting carbon from that which is consumed for heating purposes, and goes on to assert that but 1,000 kilogrammes of coal, instead of 3,000, as ordinarily used per ton, are needed according to his plan. M. Schinz says that Ponsard and Boyenval's patent is not much more than the ordinary test process of the laboratory on a larger scale; the only difference being that, whereas in the ordinary trials a surplus of carbon and scoriæ is added, he, M. Ponsard, used merely the exact quantity requisite for carbonising and smelting. This process, however, is the same as that going on in the hearth of the blast-furnace when the ores arrive there unreduced. The peroxide of iron (or sometimes the oxide) is reduced by the contact with solid carbon. This reduction, however, is not confined to the oxides of iron alone; other substances contained in the scoriæ are effected in the same manner and yielding sulphur, phosphorus, silicium, &c., which are by no means desirable companions for the produced article. In the blast-furnace, hot air and an insufficient supply of scoriæ generally produce this bad effect partly; while Ponsard's apparatus is so arranged as to have it throughout. The resulting inferior material will have to be refined, and, in that case, the inventors can hardly claim to have saved anything by their so called direct production.—*The Engineer.*

LURMANN'S BLAST FURNACE.—A considerable number of German ironmasters have, during the last two years, applied to their furnaces the system of Mr. Lürmann, the manager of the Georg-Marien Mining and Iron Company, of Osnabrück, Prussia, the improvement consisting in closing the front of the hearth, thereby dispensing with the dam stone, tymp, &c. A scoria outlet is set in the closed breast at a distance of about 6 in. below the tuyeres, and through this outlet the slag runs off regularly and constantly. The tapping hole is placed where the heat is greatest.

This arrangement has been successfully worked for six months or more at the Old Park Ironworks, Shropshire, and more than one of our leading ironmasters have expressed their intention of adopting it. Its advantages are thus enumerated:

1. The slag discharges itself through the scoria outlet at about the same level, therefore there are no vacillations of the slag in the hearth, and the corroding of the wall is diminished.

2. As there is no fore-hearth, there are of course no repairs, and no breaking up of the scoria-crust in the same. This is equal, as shown above, to a saving of at least 20 days per year. Suppose a large furnace produces 40 tons per day, the same will yield at least 800 tons per year more, if built on Mr. Lürmann's principle, than if it were of the ordinary construction.

3. As there are no interruptions, the furnace does not cool. It works more regular, as the heat in the furnace is always the same.

4. The doing away with the dam and the fore-hearth allows the removal of the tapping-hole from the former into the wall of the hearth. The opening of the tapping-hole is then easy, as it is close to the greatest heat.

5. The completely closed earth allows a con-

siderable increase of the pressure of the blast, because a throwing out of materials has become impossible.

6. The increase of the pressure is always of great importance, but especially where pit coal, anthracite, &c., are used; and where the layers are compact. The number of charges can be greater, effecting a corresponding increase of produce.

7. The augmentation in the number of tuyeres, and the equal distribution of them, made feasible by the doing away with the forepart of the hearth, allow a better and equal distribution of the blast in the hearth; the furnace therefore works better, and a greater quantity of ore is smelted, provided there is sufficient blast.

8. The number of hands may be lessened, as the operations are few and easy; the same need not be of great skill and experience. No fire clay and other refractory materials for the repairs, and less tools are wanted. It may be mentioned that formerly the smelters of Georg-Marien-Hütte, when working, were almost stripped; now they are always in full working dress.—*The Engineer.*

THE CAMBRIA IRON WORKS.—The largest iron works in the country are the Cambria Works, at Johnstown, Pa. They cover an area of about five acres, run night and day, and give employment to about 3,000 hands. They contain 42 double furnaces, over each of which is a steam boiler connected with the engine. The engine is a vertical one of 350 horse-power; its fly-wheel is 30½ ft. in diameter, and weighs 56 tons. The capacity of the works is 1,400 tons of railroad iron per week. Last year they turned out 76,000 tons, and this year expect to produce 82,000.—*Am. Artizan.*

The engine referred to is that of the new puddle train, a three high train 5 rolls long, with two squeezers. There are besides, another puddle train, two rail trains and various small trains, each with its engine. The Bessemer Steel Works of the Company, adjoining the iron works, and capable of producing 50 tons of ingots per day, are also nearly completed.—ED. V. N. M

STEEL RAILS AND THEIR USE IN AMERICA.—We quote the following from a comprehensive article in the New York "Tribune": The report of the exhaustive and important discussion held last year by the Institution of Civil Engineers in England, sums up the case in these words: "There can be no doubt as to the expediency of employing steel rails, even on railways where the traffic is light; but, of course, the heavier the traffic the greater will be the economy of substituting steel for iron."

In view of this forcible verdict in favor of steel rails, it becomes a matter of great public interest to know to what extent these rails are being laid in the United States. The report on railroads of the State Engineer and Surveyor of New York, prepared by S. H. Sweet, Deputy, and copied from the advance sheets, into "Van Nostrand's Eclectic Engineering Magazine" for last June, says: "It is estimated that from 40,000 to 50,000 tons of steel rails are in use on our various railways." Careful researches, made in this city during the past week, warrant the use of much more encouraging figures, and authorize the assertion that by the end of the year 1869 there will be laid in the United States, in round numbers, 110,000 *tons of steel rails*, equal to 1,100 miles of steel road; and of this amount about 36,000 tons, equal to 360 miles, will be laid during the present season! These rails are in use on more than 50 different roads, and are partly of American, principally of English, and to a very small extent, of Prussian manufacture.

Four large steel works for making rails have already been established in this country, and a fifth is nearly completed. John A. Griswold & Co., proprietors of the Bessemer Steel Works of Troy, N. Y., made about 2,000 tons of steel rails, half of them for the Erie railroad, prior to the burning of their works in October, 1868. None of these rails have broken, and official certificates testify that they are equal to the best foreign rails. The new works, now nearly completed will enable the proprietors to produce steel rails at the rate of 15,000 to 20,000 tons per year. The Pennsylvania Steel Works, at Harrisburg, are now, and have been for some time producing steel rails at the rate of 12,000 tons annually. These are mostly laid on the Pennsylvania Railroad, and the official reports show them to be equal to the best foreign rails. The yearly capacity of the works is 20,000 tons. The Cleveland Rolling Mill Company are producing steel rails at the rate of 6,000 to 8,000 tons per year. They have only recently started and are not yet in full operation. Their capacity is 15,000 to 20,000 tons per year. Their steel is of Lake Superior iron and is of excellent quality. The Freedom Iron and Steel Works at Lewistown, Pa., are producing rails for the Pennsylvania and other roads at the rate of some 8,000 tons per year. Their annual capacity is 10,000 to 12,000 tons. Their steel is pronounced by the Pennsylvania Railroad Company, after rigid tests, equal to the foreign. The Cambria Iron Company have a Bessemer steel works nearly completed at Johnstown, Pa. Its capacity will be 20,000 tons. The above statements are authoritative and clearly indicate that we shall be able, by next year, to produce annually at least 80,000 tons of good, American-made, steel rails, a fact full of promise for the future of American railways. It may also be stated here that the proprietors of one of the largest iron rail-making establishments in Pennsylvania, after struggling vainly for four years against the rising steel-rail tide, are now negotiating for the services of able and experienced German engineers and metal-workers, with a view to immediately establishing steel works, at which they confidently expect, within a year, to produce steel rails equal to the best for $75 a ton, which is less than the present price of good iron rails! The report quoted above states that some 7,000 tons of domestic steel rails have already been laid, and it is certainly safe to assume that 5,000 tons will be laid this season, making a total in round numbers of at least 12,000 tons (120 miles) of American steel rails in use in the United States at the end of 1869.

The great advantage of steel rails lies in their homogeneity. An iron rail, or a steel-headed rail, is made of a pile of bars heated and welded together, but a solid steel rail is rolled from a single ingot, and consequently is subject to wear only, whereas the others are exposed to "wear and tear," and the "tear," as any one must know who has ever noticed the battered, laminated, and disintegrated condition of iron rails, on a much used track, is a most serious consideration. So great is this advantage that a single steel rail has been

known to outwear no less than 23 iron rails placed successively in the same track, and it is perfectly safe to say that any good solid steel rail will outlast a dozen rails of iron. The argument that steel rails are worthless when once worn out never had much force, and is now entirely upset by the discovery of the Martin process, by which old steel can be reworked with perfect ease. And the grand objection that steel is brittle, and, therefore, steel rails must break, is now fully overthrown by actual experience. Of course steel rails may be made so brittle as to be worthless, and it is well ascertained that punching holes in them has a most injurious effect; but this process is now discontinued, and it is certain that rails rolled from good Bessemer steel and drilled, instead of punched, are not only far more durable, but are at least as tough as the best iron rails.

STEEL AND STEEL-HEADED RAILS.—The following is Mr. Abram S. Hewitt's circular to railway managers, containing the conclusions arrived at during his late investigations in Europe on this subject:

Having made a visit to Europe during the past summer, with Mr. John Fritz, Manager of the Bethlehem Iron Works, at Bethlehem, Penn., for the purpose, mainly, of acquiring information in regard to the use of steel for rails, I do not think that I can render a more acceptable service to the railroad interests of the United States than by making a brief statement of the conclusions at which we arrived.

First.—It appears to be certain that on all roads doing a large business, and especially where heavy engines are run at a high speed, steel must be substituted for iron, on the wearing surface of the track. The steel may be either puddled, or made by the Siemens-Martin, Bessemer, or crucible process; but, whatever kind of steel may be employed, care must be taken that the steel be of good quality, and adapted to the purpose. This demands skill in the manufacture, and care in the inspection. Unless this skill is used, and care exercised, there will soon be the same complaint in regard to the quality of steel as has existed in regard to the quality of iron.

Second.—For roads having a small traffic, iron rails are, as yet, more economical, provided light engines and moderate speed are employed. If proper care is used in the manufacture and inspection, and a price paid sufficient to cover the cost of good materials and workmanship, there is no more difficulty now than there was in former years in procuring iron rails of good quality. The real cause of the inferiority of modern rails appears to be due solely to the unwillingness of railroad managers to pay a price adequate to meet the actual cost of good iron and skillful work.

Third.—The question as to whether all steel rails, or iron rails with steel heads, should be used, is mainly one of first cost. There have been slight objections to steel-topped rails, when cast steel is used for the head arising out of the liability of the steel to separate from the iron, but this objection is now removed both in Europe and in this country, by the experience which has been gained at Dowlais in Wales, and at Trenton in New Jersey; and it is safe to affirm that steel and iron can be certainly united so as not to separate in the weld. The experience with the Booth rail on the New York Central Railroad also goes to show that it is not necessary to weld the steel and the iron at all, leaving it merely a question of prime cost as to whether the heads shall be welded or not. As to all steel rails, whether made from Bessemer, Martin-Siemens, or crucible steel, the only objection appears to be in their liability to break in very cold weather; but the percentage of such accidents is very small—and all things considered, it is difficult to decide whether this objection is of more weight than the possibility of a separation of the steel from the iron in the steel-topped rails.

On the whole, we came to the conclusion that we would take either the *ail-steel* or the *steel-topped* rails properly made, giving the preference to the one which could be supplied at the lowest price per ton. In other words, we believe that the question of first cost should alone decide whether to use steel-topped rails or rails made entirely from steel, provided the quality of the materials used and the workmanship is equally good in both cases. The Siemens-Martin process has solved the only difficulty which existed in regard to steel rails when worn out, by working them over as the raw material for new rails. This process is now in operation at most of the leading works in Europe, and can be seen at work at Trenton, N. J., producing steel which welds perfectly to iron, and therefore admirably adapted for steel tops.

THE MANUFACTURE OF STEEL. — The Paris "Presse" says:—"An experiment of a most interesting character, and having the highest interest for the iron industry, has taken place at the Marquise Stock Works, in presence of two eminent persons of the Ecole Centrale. The object of this experiment was to make steel by one operation, a problem which has engaged all metallurgists, and if solved, would cause an industrial revolution. M. Aristide Berard, an engineer whose name is familiar to all who have occupied themselves with this question, proposed to change second class metal in course of refining into steel of at least ordinary quality, by means of a process alternately oxidizing and reductive. His efforts have been crowned with success. The product obtained by his process, in presence of two competent judges, proved to be steel of good quality, suitable for all purpose, and made with the facility necessary to its application to practical industry. The operation was effected in a reverbatory furnace, lasted about an hour and a half, and was accomplished with as much facility as puddling. In this process, instead of acting on 480 pounds of metal to obtain iron of number one quality, from 6,600 to 11,000 pounds of metal is made by only one operation into steel ingots ready for the workshop, and with an unexpected economy. We will be much deceived if this invention has not in it the germ of a complete revolution in metallurgy."

THE SIEMENS FURNACE.—In a paper before the Iron and Steel Institute, Mr. Josiah T. Smith, of the Barrow works, after noticing in detail the application and effect of the gases, added that for many months each producer at Barrow had volatilized 3 tons of coal per 24 hours, and that the greatest economy effected was when the consumption had not exceeded 50 cwt. Estimating the weight of one cubic foot of gas at the ordinary temperature of thin air to be .075 lbs., the volume of carbonic oxide, hydrocarbon and hydrogen, from

one ton of coal would be about 53,000 ft., and the volume of nitrogen about 122,000 ft., or making together a total of 175,943 ft. The consumption of coal in the producers at Barrow being 500 tons per week, it gave an amount of gas passing through the tubes at the rate of 6¼ ft. per second, of 87,000,000 cubic feet; or through the various furnaces adding the quantity of air there admitted of 6,600 tons. The saving of fuel by this process at Barrow was, over a period of two years, no less than 44 per cent; but the actual money saving, by the use of a particular kind of coal, had been more than one-half. The yield of the gas furnaces, taken over the same period, showed a saving of 31 per cent as compared with the work at the firing furnaces, and the amount of repairs was just two-thirds of the old cost. In these three particulars was undoubtedly to be found the chief economy; but the adoption of the system enabled them to preserve greater cleanliness and order in their works, and an entire absence of smoke met a difficulty which, in the neighborhood of large towns, was every year becoming a greater grievance. There was, he admitted, a slightly increased outlay on the plant; but taking into consideration the increased capabilities as to quantity, it would be found to represent the difference in cost between the two systems.

IRONMAKING IN THE CLEVELAND DISTRICT.—For economizing the use of coke in the blast-furnaces their height has been increased from time to time, from 45 ft. to 95 ft. and upwards. Several of the original 45-ft furnaces are still standing in the neighborhood of Middlesborough, but disused. It has been found at the five furnaces of Messrs. Bolckow and Vaughan that the furnaces of 95 ft. high and 16 ft. bosh are a little more economical as to the use of coke than the other three furnaces of the same height; two of them are 23 ft. and the other 22 ft. in the bosh; the capacity of the latter is about 20,000 cubic ft., and of the former about 10,000 ft. The production of pig-iron will not be in the same ratio, but is greatly augmented in the larger capacity. Another question of economy is the heat of the blast. It appears that with the blast heated to 1300° in high furnaces, 22 cwts. of coke are required in reducing 1 ton of pig-iron, and 1 cwt. of coke is saved for every 100° increase of blast, from 650° to 1150° and upwards. As the blast is heated invariably with the waste gases of the blast-furnace, this saving represents a direct economy in fuel. The blast-furnaces in the Cleveland district are closed at the top with bells, with the exception of the furnaces at Grosmont, the gases from which are withdrawn by means of chimney draught. At the furnaces of Messrs. Bolckow and Vaughan calcining kilns, 45 ft. high, 21 ft. in diameter, are erected of 18 in. fire-bricks, covered with ¼-in. plates. The yield of iron from raw ore is about 30 per cent. One ton of coal will calcine about 40 tons of ironstone in these kilns; the calcined stone is let out from the bottom of the kilns direct into barrows. The coke is deposited in hoppers, and is let out at the bottom into barrows by sluices, and afterwards raised to the top of the furnaces. The mode of raising materials from the ground to the top of the furnaces in most cases is by water-balance, the supply water being pumped into a tank by a steam engine. Two works have hydraulic hoisting apparatus, some by pneumatic pressure, and others by direct steam power.—*Mining Journal.*

KRUPP'S BESSEMER RAILS.—The manufacture of Bessemer steel rails is now very extensively carried out in the works of Herr Krupp, at Essen. There are four converters used only for rail making. The steel ingots obtained are cylindrical, one ft. six in. diameter, and five ft. high. These ingots are hammered under a steam hammer of eight tons, and reduced to an octagonal section twelve in. wide. They are then rolled through a rolling mill worked by a 100-horse power horizontal and direct-acting engine. This engine, which is not condensing, runs at 50 revolutions per minute, and has a fly-wheel 46 ft. diameter, weighing 60 tons. The ingot is thus converted into a rectangular bar 5⅜ in. thick and 7⅜ in. wide; this bar is divided into six or eight pieces, under a steam hammer of four tons. Each of these pieces is used for making rails; they are rolled through a steam rolling mill worked by a 500-horse power steam engine to the speed of sixty revolutions per minute. This system of manufacture enables us to get rid of the globules which have been ere now the most grievous defect of the steel rails, and which are more easily expelled from a large ingot than a small one.—*The Engineer.*

WROUGHT-IRON CHIMNEY.—A new wrought-iron chimney has been recently erected at the Creusot Ironworks. It is 197 ft high and 6 ft. 7 in. diameter. At the bottom the diameter is increased to 10 ft. by a curved base, which is fastened by vertical bolts to masonry work. The thickness of the sheet-iron is 3-32 in. at the top, and 7-16 in. at the bottom. There is an inside iron ladder. The weight of this chimney is 40 tons; it has been riveted horizontally, and lifted afterwards with a crane. Another one, 275 ft. high, will be soon erected, but by a different system; it will be riveted vertically, with an inside scaffolding. These chimneys are built for an extension of the Creusot Works, especially intended for steel making. There will be eight Bessemer converters, where the cast-iron will be run direct from the blast-furnace; there will be also many Martin's furnaces, and an extensive workshop for melting steel in crucibles, where it will be possible to melt together 50 tons of steel.

ACCIDENT AT A BESSEMER WORKS.—A serious accident has occurred at the Atlas works, belonging to Messrs. John Brown & Co. (Limited) at Sheffield. Six men were engaged in casting an immense ingot, when the vessel, which contained about seven tons of molten metal, was overturned, in consequence of the chain which balances it giving way. The whole of the red-hot steel was cast upon the floor. Three workmen were very severely burned. The metal spread all over the floor of the workshop, which is situated in the Bessemer department of the manufactory, and several other workmen, who were some distance from the moulding apparatus, had very narrow escapes.

PRODUCTION OF RAILS IN FRANCE.—A table which has been prepared in illustration of the production of rails in France during the last ten years presents the annexed results: 1859, 101,426 tons; 1860, 121,438 tons; 1861, 164,371 tons; 1862, 216,175 tons; 1863, 226,948 tons; 1864, 215,983

tons; 1865, 184,131 tons; 1866, 159,061 tons; 1867, 154,351 tons; and 1868, 202,204 tons. The average price per ton in 1859, was £10 2s. per ton, while, in 1868, it had fallen to £7 2s. per ton.

BRITISH BLAST-FURNACES.—The number of furnaces in blast, in 1868, was 560; and the make of pig iron in Great Britain amounted to 4,970,206 tons, an increase of 209, 183 tons over 1867. In England the make was 2,970,905 tons, an increase of 159,959 tons; in Wales and Monmouthshire, 931,-301 tons, an increase of 12,221 tons; in Scotland, 1,068,000 tons, an increase of 37,000 tons.

MAGNETIZATION OF IRON AND STEEL.—At a recent meeting of the Academy of Sciences, at Vienna, Herr A. Waltenhofen read a paper on the limits of the magnetization of steel and iron. As a general result he finds the potential temporary magnetization of iron to be about five times greater than that of the best steel.

CATASAQUA MANUFACTURING CO.'S IRON.—Tests at the Scott foundry, Reading, give specimens of three brands of this iron—66,000 lbs., 68,400 lbs. and 74,600 lbs. tensile strength, respectively.

STEEL BOILERS.—Messrs. D. Adamson & Co. are now making steel boiler shell rings in one plate, measuring 27 ft. in length, and weighing upwards of 16 cwt. each.

ORDNANCE AND NAVAL NOTES.

THE "INCONSTANT."—This fine frigate, of 4,060 tons measurement, 1,000-h.p. (nominal), carrying as her armament ten 12 ton 9 in. and six 6½ ton 7in. muzzle-loading rifled guns, mounted on iron carriages and slides—the pioneer of the new type of unarmored iron-built war frigates introduced into the English navy by the present Chief Constructor—has been put through her official speed trial at her load draught of water over the measured mile in Stokes Bay, near Portsmouth, and by the exceptionally high rate of speed she attained more than confirmed the strongly favorable opinions of her powers created by her previous performance on her preliminary trials, and also exceeded the estimate of her speed given in officially to the Admiralty by her designer. The speed trials of the Inconstant are without doubt the most important by far of all that have yet been made over the measured mile in this country. She is a war frigate designed for special services, requiring exceptional speed under steam, and in all respects intended for competition with the flying unarmored war frigates lately added to the American Navy, and whose powers for offense and flight under steam have been so highly eulogized in the official documents reporting upon their trials and handed in by the officers conducting them to the secretary of the United States Navy. In the American official documents the Wampanoag was said to have steamed at the rate of 16.7 knots per hour for 37 consecutive hours, in a strong beam sea and wind, over a given distance along the coast line. This was stated in the reports to have been done by the Wampanoag, at her proper seagoing trim, and with all weights on board; but now this is flatly contradicted on this side the Atlantic, and the Wampanoag is asserted to have attained her extraordinary rate of speed under conditions different from those given in the official reports. It would be of some value to us to learn the exact truth relating to the trials of the American unarmored frigate, in order that we might obtain some reliable standard by which we could measure the value of our own frigates of a similar character. Sixteen and three-quarter knots per hour continued for 37 hours by the Wampanoag is, on the face of the assertion, an almost incredible performance for any ship carrying 15 in. guns and exceptionally heavy weights in engines and boilers, unless she was greatly assisted by her sails, and until some precise information be given as to how the distance run in the 37 hours was arrived at, the Wampanoag will be only considered really to be what she is asserted to be in this country—a 14 knot ship; and in that case the Inconstant is the faster ship of the two by 2¼ knots per hour.

On weighing her anchor from Spithead for her trial the Inconstant drew 20 ft. 8 in. of water forward and 24 ft. 7 in. at the stern. She did not carry her crew, powder and shell, and a quantity of stores, but the weight of all these matters was placed on board for trial in the shape of iron ballast, and, in addition, she carried about 40 tons extra weight in coals, &c., so that her trials were made at a draught of water an inch or so in excess of what it will be when the ship actually proceeds to sea.

Subjoined are the results of the trial. Full boiler power, measured mile runs:

No. 1.—Speed of ship, 16.901 knots; revolutions of engines—per mile 259, per min. 73.5; steam, 30 lbs.; vacuum—forward 25.5, aft 25.5.

No. 2.—Speed of ship, 15.385 knots; revolutions of engines—per mile 287, per min. 74; steam, 30 lbs.; vacuum—forward 25.5, aft 25.5.

No. 3.—Speed of ship, 17.822 knots; revolutions of engines—per mile 252, per min. 75; steam, 30 lbs.; vacuum—forward 25.5, aft 25.5.

No. 4.—Speed of ship, 15 knots; revolutions of engines—per mile 298, per min. 75; steam, 31 lbs.; vacuum—forward 25.5, aft 25.5.

No. 5.—Speed of ship, 18.367 knots; revolutions of engines—per mile 269, per min. 75.5; steam, 30 lbs.; vacuum—forward 25.5, aft 25.5.

No. 6.—Speed of ship, 14.754 knots; revolutions of engines—per mile 304, per min. 75.5; vacuum—forward 25.5, aft 25.5.

Mean speed of the ship under full boiler power, 16.512 knots per hour! Mean revolutions of the engines during the six runs, 74.48 per minute; mean steam pressure, 28.825 lbs.; indicated power by the engines, 7,343 horse.

Full boiler power circles, 12 men at the wheel:

To Port.—Half circle made in 3 min. 25 sec.; full circle made in 6 min. 48 sec.

To Starboard.—Half circle made in 3 min. 11 sec.; full circle made in 6 min. 10 sec.

Half boiler power, measured mile runs:

No. 1.—Speed of ship, 15.789 knots; No. 2.—Speed of ship, 11.613 knots. Mean speed of the ship under half boiler power, 13.701 knots per hour; mean revolutions of the engines, 59.95 per minute. Mean steam pressure, 14.227 lbs.; indicated power by the engines, 3,532.29 horse.

Half boiler power circles, 14 men at the wheel:

To Port.—Half circle, 3 min. 56 sec.; full ditto, 7 min. 50 sec.

To Starboard.—Half circle, 3 min. 42 sec.; full ditto, 7 min. 6 sec.

The Inconstant has a balanced rudder like the Bellerophon. Hercules and Captain, but in her case

the fore part of the rudder was reduced in area very considerably the last time she was in dock, and perfect command is now kept over the ship by the men at the wheel, however far the helm may be put over. On her light draught trial the vibration on board was found to be very great, but since the ship has been brought down deeper in the water this has been materially lessened and when the engines were being driven at their highest speed, the vibration exhibited by the hull of the ship was nothing at all extraordinary or beyond what is usually felt under such circumstances. The engines, which were in charge of Messrs. Anderson and Knight, as the representatives of the manufacturers Messrs. John Penn & Son, gave satisfaction in every respect to the Government officials on board.—*Artizan.*

WAR EXPENDITURE.—The annexed table is extracted from a paper on war taxation, by Mr. William Stokes, which was recently read before the National Reform Union, at Manchester. Mr. Stokes' object was to set forth the permanent consequences of what he terms profligate war expenditure and periodical invasion panics. The conclusion he draws from the figures is that the industry, trade and manufactures of Great Britain are more shackled and burdened by needless taxation than those of any other nation:

	National debt. £	Amount per head. £ s. d.
1. Ducal Hesse	228,916	0 5 4
2. Sweden	4,114,880	1 0 0
3. Norway	1,854,157	1 1 10
4. Chili, S. America	2,933,405	1 15 0
5. Prussia (1866)	42,123,064	1 15 8
6. Turkey	69,142,270	1 19 1
7. Oldenburgh	621,585	2 1 2
8. Electoral Hesse	1,485,892	2 9 6
9. Brazil	30,762,289	3 1 3
10. Hanover	6,423,955	3 3 6
11. Russia	274,544,770	3 14 1
12. Wurtemberg	7,033,911	3 19 6
13. Saxony	9,912,049	4 4 10
14. Belgium	25,070,021	5 0 7
15. Brunswick	1,707,707	5 16 5
16. Bavaria	29,669,267	6 3 5
17. Baden	9,256,728	6 9 6
18. Austria	268,965,064	7 5 3
19. Denmark	14,862,465	8 18 9
20. Italy	211,503,298	9 8 3
21. Portugal	42,930,472	9 17 4
22. Spain	163,927,471	10 4 6
23. Greece	14,000,000	12 15 3
24. France	566,680,057	14 18 9
25. Hamburgh	4,222,897	16 16 5
26. United States	579,880,391	18 18 9
27. Holland	81,790,799	21 17 10
28. Great Britain	797,031,650	26 10 0

THE NORTH GERMAN FLEET.—The Imperial Navy of North Germany dates its origin from the year 1848, when the Danish war demonstrated to Prussia the necessity of establishing a fighting fleet and showed the position of a nation lacking this branch of military power. Denmark, a country insignificant in comparison with the German Principalities, was enabled to inflict vital injuries which they were powerless to prevent or to resent. At first the want of union among the German States made itself very strongly felt during the establishment of the fleet, and instead of a combination of all the resources at command they were wasted to create two navies—one in the North Sea, and a Prussian fleet in the Baltic. And all the money which could be gathered for the purpose was absorbed without a German fleet being created. In despite, however, of all these unfavorable circumstances the Prussian navy has so far increased, during the last twenty years, that it has developed from an insignificant fleet of gunboats to a marine, comprising thirty steam and six sailing ships, besides gunboats and vessels for harbor defenses. The navy comprises the fighting and training ships, transports, coast-guard vessels, and those for the defences of ports and harbors. Of the first named, five are armor-clad—the rest of wood, which are still considered capable of good service; the training ships being for the most part disrated sailing vessels, in which officers and seamen receive their professional training.

The following table shows the actual strength of the effective navy of North Germany:

NAME OF SHIP.	No. of guns.	Horse power.	Tonnage.
ARMOR-CLAD FRIGATES.			
Kœnig Wilhelm	23	1150	5938
Friedrich Karl*	16	950	3809
Kron-Prinz	16	800	4401
ARMOR-CLAD TURRET SHIPS.			
Arminius†	4	300	1229
Prince Adalbert‡	3	300	779
WOODEN CORVETTES WITH PROTECTED BATTERIES.			
Elizabeth§	28	400	2026
Hertha	28	400	1745
Vineta	28	400	1745
Arkona	28	386	1621
Gazelle	28	386	1621
CORVETTES WITH BATTERIES EN BARBETTE.			
Medusa	17	200	925
Nymph	17	200	925
Augusta	14	400	1462
Vittoria	14	400	1462
DESPATCH BOATS.			
Eagle	4	300	800
Loreley	2	120	332
ROYAL YACHT.			
Cricket	2	160	493
1ST CLASS GUNBOATS.			
Basilisk	3	80	326
Lightning	3	80	326
Chameleon	3	80	326
Comet	3	80	326
Cyclops	3	80	326
Dolphin	3	80	326
Dragon	3	80	326
Meteor	3	80	326

* Length, 290 ft. 4 in.; beam, 53 ft. 3¾ in.; draught, 23 ft. 9¼ in.; armor, 5½ in. thick.

† Length, 200 ft. 1½ in.; beam, 36 ft. 1 in.; draught, 13 ft. 11 in.; armor, 4 9-16 in. thick.

‡ Length, 158 ft. 6¼ in.; beam, 32 ft. 9 in.; draught, 14 ft. 10 in.

§ Length, 231 ft. 7 in.; beam, 43 ft. 3 in.

Name of Ship.	No. of guns.	Horse-power.	Tonnage.
2d class gunboats.			
Fox	2	60	233
Shark	2	60	233
Vulture	2	60	233
Hyena	2	60	233
Chasseur	2	60	233
Aspic	2	60	233
Arrow	2	60	233
Salamander	2	60	233
Nightingale	2	60	233
Scorpion	2	60	233
Sparrowhawk	2	60	233
Tiger	2	60	233
Wasp	2	60	233
Wolf	2	60	233
Sailing Ships.			
frigates.			
Geflon	48	.....	7406
Thetis	38	.....	1557
Niobe	26	.....	1052
briggs.			
Mosquito	16	.....	549
Rover	16	.....	552
Hela	6	.....	253

Besides these there are five vessels for harbor service, thirty-two yawls armed with two guns, and four with one gun each.

Two corvettes are in course of construction—the Hansa, with an armor-plated battery of eight guns, and of 450 horse power; and the Ariadne, a wooden ship, with a battery of six guns and with 360 horse power. Altogether the Prussian navy possesses 90 armed vessels of all denominations, mounting, collectively, 1,549 guns; but few of these, however, were built at any of the Imperial dockyards.—*Engineering.*

Shoeburyness Experiments on Shells and Fuses.—A series of experiments were recently conducted at Shoeburyness, with the object of ascertaining the relative efficiency of the Palliser shells, having their heads chilled and bodies cast in sand, the merits of shells made of Firth's steel, and containing large bursting charges, and to determine the reliability of a new form of fuse designed by Lieutenant E. Boxter, R. N. All the rounds were fired from the 9 in. Woolwich rifled gun, with full battering charges of 43 lbs., at a range of 200 yards, against an 8 in. plated target, with 18 in. teak backing and ¾ in. skin. Five rounds were fired with the compound Palliser projectile (having the chilled head and soft iron body), and two rounds with shells of Firth's steel, the first third, fifth, sixth and seventh rounds being with the former, and the second and fourth with the latter class of projectiles.

In the first round the Palliser shell effected a penetration of 22 in. from the back of the head, which remained in the hole, the body being blown out in front of the target.

In the second round with a hardened Firth steel shell, penetrated to a depth of 26 in., the shell bursting in the backing, and the body being blown out of the shield.

The third round with a Palliser shell, penetrated to a depth of 25¼ in., tearing away the backing, and tearing some of the backing girders.

The fourth round, a Firth's steel shell, penetrated to 8¼ in., making a hole 10 in. by 11 in. The effect of this round manifested itself in stripping off flakes of the plates in the vicinity of the point of impact.

The Boxer fuse, which has been adapted to the Palliser shell, is intended to be used in those projectiles which are fired against wooden or thinly-plated ships, which are now penetrated by shell with the same effect as by solid shot. The fuses are made of gun-metal, and are screwed into the rear of the shell through a gun-metal bushing. In the front of the fuse plug, in a cylindrical recess, is placed a small cylinder of lead behind a gun-metal hammer, which is suspended by a wire. In front is placed the fulminate upon a disc in contact with a pellet of compressed powder. When the gun is discharged the leaden cylinder is compressed, and the hammer is liberated by the shearing of the wire which suspended it, and so soon as the shock of impact occurs, the hammer springs forward, and, striking the fulminate, explodes the shell by means of the powder pellet. The act of explosion, however, occupies a space of time sufficient to allow of the passage of the projectile through the wooden sides or the thinly armored walls of a ship.

Three experimental rounds were fired with shells provided with these fuses with the object of ascertaining whether the efficiency of the Palliser projectile would be impaired when fired against thick plates. In all these rounds a complete penetration was effected, as well as a marked superiority in the amount of damage.

The experiments of the day were completed with some rounds fired from a 9-pounder Indian brass field gun, to ascertain the value of a new fuse, being a combination of the service Boxer wood time fuse and a modification of Captain Freeburn's concussion fuse, adapted for light field pieces as well as for heavy guns—*Engineering.*

Pontoons for Transport Ships.—About two years since Admiral Mends proposed the construction of pontoons for the service of the new very large transport ships Serapis, Euphrates and Crocodile. The first pontoons which were constructed for the Serapis were of cylindrical form, and were built of steel by Maudslay. Four were made to constitute the raft, the weight of each being about 2¼ tons. On the trial of them before the naval and military authorities at Woolwich, it was suggested that pontoons constructed of Mr. Clarkson's cork material would possess qualities of lightness, strength, and buoyancy peculiarly suitable for the operations such pontoons would be called upon to perform, and that they would also be more easily repairable if damaged by musketry fire. Four pontoons of the following dimensions were ordered for experimental trial, and these were launched into the Thames on Monday last. Their dimensions are: Length, 36 ft.; diameter, 4 ft. 6 in. A light framework is made of wood as the skeleton of the structure. The form is then completed by planking of ¼ in. thick pine wood, both sides of which are covered by stout canvass adhering to the surfaces by a

waterproof solution. Over this sheet cork is applied by the same adhesive substance; the whole pontoon is coated with the solution, and a strong jacket of canvass is superadded as the external covering. The advantage of this material is that it possesses elasticity and such capacity of cushioning blows that the vessel receives no injury from such concussions as would be liable to fracture or indent metal structures; and with the passage of shot there is an absence of splinters, and a natural tendency on the part of the cork material to close up the orifice made by the missile. The four pontoons were manufactured in London, and floated down the river to the factory of Messrs. Maudslay, Sons and Field, where they were fitted together by spars and lashings, and a stage or platform for landing or embarking guns, troops, horses, &c., erected upon them. The pontoon was then towed down by the Bustler, Admiralty steam tug, to Woolwich dockyard.

THE TURRET SHIP MONARCH.—The following notes of the dimensions and performance of the two-turret armored ship Monarch will be found of interest:

Length between perpendiculars	330 ft.
Extreme breadth	57 ft. 6 in.
Depth of hold	18 ft. 8 in.
Tonnage	5,102 tons.
Draught load on trial—forward	21 ft. 10 in.
" " —aft	25 ft. 8 in.
Displacement "	8,070 tons.
Engines, nominal HP	1,100.
Cylinders, diameter	120 in.
" stroke	4 ft. 6 in.
Indicated on measured mile	7,842 HP.
Revolutions, mean "	63.61 "
Indicated on six hours' trial	7,470 "
Revolutions, mean, six hours' trial,	62.67 "
Steam in boiler, measured mile	31.33 lbs.
" " six hours' trial	30.58 "
Midship section	1,208 sq. ft.
Mean speed, measured mile	14.937 knots.
$\frac{V^3 MS}{I H P}$ "	513.4
$\frac{V^3 D^{\frac{2}{3}}}{I H P}$ "	171
Mean speed, six hours' trial	14.715 knots.
Co-efficients as above	515.3 and 171.6.

The Monarch has nine boilers, containing forty furnaces, the area of grate being 770 sq. ft., while the total heating surface is 20,900 sq. ft. There are 3,600 sq. ft. of superheating surface, and the surface condensers present 16,500 sq. ft. of surface. The Griffiths' screw is 23 ft. 4 in. in diameter, and 26 ft. pitch. The armament of the Monarch consists of two 25-ton rifled guns in each turret, besides three smaller guns on deck. Each turret is 26 ft. 6 in. in external diameter, and 22 ft. inside, the solid rolled plates around the ports being 10 in. thick, while at other parts of the turrets the thickness is 8 in.—*Engineering*.

THE STEVENS BATTERY.—The celebrated "Stevens Battery" is still at the yard in Hoboken, where her keel was laid long ago. The ban of secrecy has not yet been removed from the work on the vessel, which, however, is still steadily progressing. Our reporter visited the yard yesterday, and was enabled to gain a few facts in regard to the construction of this modern marine monster. The vessel as she stands is 250 ft. in length, 30 ft. in breadth and draws 27 ft. of water. Her hull is composed of teak wood two feet in width, with a covering of four inches of iron, which is screwed on with copper bolts. Her decks are composed entirely of iron, and the battery which she is to carry, is to consist of four guns of enormous caliber, throwing a solid ball of 700 pound weight. She will have two screw propellers, and it will be impossible for her to turn within a space equal in length to that of the vessel. General McClellan is at present superintendent of the work, and he has 180 men employed. The ram is to be completed during the year 1871, when it will be presented to the State of New Jersey, as a protection to New York Harbor. Thus, says a New York Daily, very correctly, only the length of the vessel is 420 ft. instead of 250, and 45 ft. beam instead of 30; and she is built of iron instead of teak. ED. V. N. M.

IMPROVEMENTS IN MUSKETS.—The equipment of a musketeer, as late as 1689, was very cumbrous. He was provided with a heavy wooden fork, which he had to stick into the ground with the prongs uppermost, to serve as a support for his matchlock, which he had to load with his powder-horn and measure, keeping the ball meanwhile between his lips. The wadding he had to get from his hat. Nevertheless, the wheel-lock, provided with pyrites instead of flint, had long been invented, but seems never to have come into general use in armies, except for cavalry pistols. The French lock which preceded the percussion system was invented as early as 1640, though it, of course, received successive improvements. But even before that time Gustavus Adolphus had introduced a great improvement in musketry, by reducing the weight of the piece to 10 lbs. instead of 15 lbs. This enabled the soldier to do away with the fork, and therefore increased the rapidity of the fire. The bullet weighed an ounce. Another improvement of his was the paper cartridge, which, however, at first only contained the powder, the bullets being kept in a bag.

PALLISER MORTAR.—A 13 in. sea service mortar of five tons weight has been ordered to be converted upon Major Palliser's plan into a 9 in. rifled mortar of about 6¼ tons weight, to fire the 9 in. service rifled shell, which contains a bursting charge of 18 lbs. of powder. The bore of the mortar will be elongated to about 4 ft. 6 in.; and a range of about 7,000 yards is expected to be obtained from a charge of 20 lbs. of powder. Some further experiments are being carried on with two 10 in. shell guns, which are being converted respectively into an 8 in. and a 7 in. rifled gun, in order to determine the most suitable caliber for the conversion of cast iron 10 in. shell guns. The whole of the 212 8-in. guns converted into 6 3 in. rifled guns by Sir Wm. Armstrong & Co. have been passed into the service, and 200 more are in course of conversion in the royal gun factories. It is probable that a considerable number of guns will be converted next year for land defenses, the whole of the above 437 guns being for the navy.

HARVEY'S SEA TORPEDOES.—A considerable number of these formidable machines have been supplied by the maker, Mr. William Nunn, of St. George street, London Docks, to the Russian Government.

FOREIGN 20-IN. GUN.—Some interesting experiments have taken place at Perm with a new 20 in. gun, cast in the foundry of that town. The trials made with this gun, under the direction of Major General Prestitch, commandant of the Cronstadt artillery, are described in the officiale rports as having been very successful, and more satisfactory in their results than had been the case with American guns of the same caliber. The gun was fired 314 times; the projectile weighs 10 cwt., and the charge of powder required for each shot was 130 lbs. The weight of the gun is about 50 tons, the recoil 7 ft., the initial velocity of the projectile 1120 ft. per second, and the percussion force at a distance of 50 ft., about 10,000 tons. The official papers say this is 'the most powerful gun in Europe.

EXPLOSIVE COMPOUNDS.—Mr. F. A. Abel, has communicated a long paper to the Erench Academy on the properties of explosive compounds, which contains the results of experiments with gun-cotton, gun-powder, nitro-glycerine, &c. He accounts for the difference remarked in the nature of the explosion produced by various substances when they act upon matter of a different kind by supposing that the explosion produces a certain kind of vibration that may or may not be synchronic with that produced in the body operated upon by the explosion.

ARMSTRONGS FOR GREECE.—The screw steamer Hotspur has lately sailed from Lynn for the Tyne, and taken on board a cargo of Armstrong guns. These Armstrongs are intended for the Greek government.

RAILWAY NOTES.

GREAT WESTERN NEW NARROW GAUGE ENGINES. —The following are the principal dimensions of the new locomotive engines of the Great Western Company. The boiler is 10 ft. 6 in. in length, and 4 ft. diameter inside. It is of 7-16 in. plates, the tube plates are $\frac{5}{8}$ in., the angle irons $3\frac{1}{4}$ in., the rivets $\frac{3}{4}$ in. diameter, are $2\frac{1}{4}$ in. between centers; there are six stays of an inch diameter, and two gusset stays. The outside fire-box is 5 ft. 1 in. long, by 4 ft. $1\frac{1}{4}$ in. broad, and as regards height is flush with the barrel; it is 2 ft. 8 in. below the boiler, and is of 7-16 in. plates, bound by $\frac{3}{4}$ in. rivets at $1\frac{7}{8}$ in. centers; it has 540 stays $\frac{7}{8}$ in. diameter; the distance of the copper stays apart average 4 in. The inside fire-box is of copper, and is 4 ft. 6 in. long by 3 ft. 6 in. wide, and is 5 ft. 6 in. from the bottom to the top of the box; it has nineteen fire-bars 1 in. distance apart; the area of the fire-grate is 15.75 ft. The superficial area of the box is 87 ft.; the steam-pipe is 5 in. diameter. The tubes. iron, are 10 ft. $9\frac{3}{4}$ in. long; in outside diameter 2 in. and $1\frac{7}{8}$ in.; they are $2\frac{5}{8}$ in. between centers, and in number are 161 of 2 in. and fourteen of $1\frac{7}{8}$ in., or 175 in all, giving a superficial area of 999 square feet, and a total heating surface of 1,086 square feet. The smoke box is 2 ft. $5\frac{3}{4}$ in. in length, by 4 ft. $8\frac{1}{4}$ in. broad, and of $\frac{1}{4}$ in. plate. The chimney is 1 ft. 4 in. diameter, of $\frac{1}{4}$ in. plate, and has an extreme height of 14 ft. 6 in. above the rail. The blast pipe, of cast iron, is $4\frac{3}{4}$ in. diameter at the top, and is 3 ft. 6 in. high. The pumps, brass, have a 2 ft. stroke, with a plunger $1\frac{3}{4}$ in. diameter. The diameter of the waterway is $2\frac{1}{4}$ in.; distance of centers, 3 ft. 7 in.; rise and fall of pump clack seat 3-16 in. The safety valves, brass conical, are 4 in. diameter, with 3 ft. centers of levers. The cylinder is 16 in. diameter; stroke, 2 ft.; distance of centers, 2 ft. 3 in.; distance below boiler, 1 ft. $5\frac{1}{4}$ in.; distance of centers of valve spindles, $4\frac{1}{4}$ in. The back and front flanges have ten bolts, $\frac{7}{8}$ in. diameter, in each. The cylinder is $\frac{7}{8}$ in. thick; the piston rod $2\frac{1}{4}$ in. diameter. The distance between inside of ports is 2 ft. $1\frac{1}{4}$ in. The ports are 1 ft. 2 in. in breadth; length of steam, $1\frac{3}{8}$ in.; length of exhaust, $3\frac{1}{4}$ in.; thickness of bridge, $\frac{3}{4}$ in. The slide valves travel 4 in.; the lead is 3-16 in. to 5-16 in.; lap on steam side, 1 1-16 in.; and the eduction overlap, $\frac{1}{4}$ in. The four eccentrics of cast iron, with patent white metal rings, have 3 1-16 in. throw; diameter, 1 ft. $2\frac{3}{8}$ in.; breadth, $3\frac{1}{4}$ in. The regulator, cast iron, with brass slide, has two steamways, $6\frac{1}{4}$ in. by 1 in. The motion bars are 4 ft. $2\frac{3}{4}$ in. long, 3 in. broad, and $2\frac{7}{8}$ in. apart. The driving-wheels are 5 ft. diameter; the outside tire is $5\frac{5}{8}$ in. broad by $2\frac{5}{8}$ in. thick; the wheels are 4 ft. $5\frac{1}{4}$ in. apart; and the cone of the wheel is 1 in 15. The leading wheels are 3 ft. 6 in. in diameter; distance of wheels same as the driving-wheels; cone of wheel, 1 in 10. The trailing wheels are 5 ft. diameter, same distance apart; cone 1 in 10. The distances of the centers of the wheels are—driving-wheels from leading wheels, 7 ft. 3 in.; driving-wheels from trailing wheels, 8 ft. The laminated steel springs for the driving axle are 3 ft. $5\frac{1}{4}$ in. long by 4 in. broad, and consist of fifteen plates, giving a depth of $5\frac{3}{4}$ in. at the center. The springs for the front axle have seventeen plates, and are $6\frac{1}{4}$ in. thick in the center. The extreme length of the frame is 25 ft. 2 in., and the breadth 4 ft. $4\frac{3}{4}$ in. The buffers are 3 ft. 3 in. in height from the rail, and 5 ft. 10 in. between centers. The suction pipes, of copper, are in height 1 ft. 3 in. from the rail; distance of centers 3 ft. 9 in.; diameter of waterway, $1\frac{3}{4}$ in. A tender to these engines needs no description, seeing that they have none. They (the engines) are supplied each with two tanks fixed on platforms over the frames; the capacity of the tanks is 395 gallons each. Coal is carried in a bunk at the back of the foot plate. The tank capacity of an engine, it will be seen, is 790 gallons, but in practice they are never charged with this quantity. The tanks are usually filled to a height of about 13 in. from the top, this restricted height being found necessary for the efficient working of the condensing apparatus. With water to this level, and with coke and sand-boxes full, ready for a trip, the loaded engine is 33 tons 4 cwt. in weight, borne thus:—Leading wheels, 9 tons; driving wheels, 12 tons 2 cwt., and trailing wheels, 12 tons 2 cwt. The weight is reduced to about $31\frac{1}{4}$ tons at the end of a moderate journey. These engines, it may be repeated, have more than fulfilled all the expectations that were entertained concerning them when they were designed and constructed. We have already had occasion to speak favorable of them in our impression for May the 14th. The weight of the various engines now working the Metropolitan Railway, is about as follows:—Metropolitan Company's engines, 42 tons nominal; Midland engines, 45 tons nominal; Great Northern engines, 33 tons nominal; Great Western narrow gauge, 33 tons 4 cwt. actual.—*The Engineer.*

UNDERGROUND RAILWAY LOCOMOTIVES. — Mr. Buckhout, in his report on the New York City Central Underground Railway, describes a general design, and comments as follows:—Gauge, 4 ft. 8½ in. Fuel, anthracite coal or coke. Cylinder, 14 by 22 in., four 56-in. driving wheels, steel tyres, all flanged. Two single axle radiating trucks, one at each end, wheels 30 in. in diameter. Furnace of steel; 126 two-in. flues, 10 ft. 5 in. long. Tank on each side of engine to contain 1,500 gallons. The engine also to be supplied with a blower or steam jet. The engine to be so arranged as to throw the exhaust steam into the tanks so as to condense it, or throw it up the chimney for the purpose of blast for raising steam, and so that the engineer can make the change instantly as required. This engine will take 80 tons in addition to its own weight (68,000 lbs. in running order), with 1,500 gallons of water in the tank, and 600 lbs. of coal, up grades of 1 in 39, or 38 ft. per mile, with a pressure as low as 80 lbs. per in. (if the steam should get so low), cutting off at 60 per cent admission, it being intended to carry a maximum of 130 lbs. per inch. About 1,400 gallons of water will be required for the condensation of the steam for the distance of two miles. consequently it would require changing every four miles, if the steam were condensed for half that distance. The tanks to have a discharge valve by which the water can be let out quickly, when it requires changing. The fixed wheel base to be 6 ft 9 in., and the whole base, including the radiating trucks at each end, to be about 21 ft. 9 in. With this arrangement the truck wheels will not require to radiate over 3¼ in. from a straight line, on curves of 200 ft. radius, which is much within the limits of its capability. With equalizing levers, as applied to this description of engine by Mr. Hudson, two-thirds or more of the weight can be carried on the drivers, and the arrangement is such as to accommodate itself to all the vertical and lateral undulations of the track, without varying the distribution of the weight on the wheels; it is also arranged so as to be equivalent in action to a four wheel center bearing truck at one end, and to a four wheel side bearing truck at the other end. In addition to these properties the engine can be run either end foremost with *great facility and equal safety*: a feature not embraced in any four driving wheel single truck engine. It has therefore special advantages in saving the time usually occupied in turning an engine around so as to run truck foremost. It has another advantage. The trucks do not deviate from the center line of engine nearly as much as a faur driving and four wheel swing truck engine does on the same curve, being some 50 per cent in favor of the double truck.

COAL AND SMOKE CONSUMPTION, ON THE PENNSYLVANIA RAILWAY.—In 1859, arrangements were made for a thorough and favorable trial of the Gill patent for smoke and gas consumption, and in the Report for that year (13th A. R.) the Master Mechanic expressed himself as satisfied that "the true secret of consuming smoke has been discovered and rendered practicable." This plan included a "combustion chamber," which it was hoped could be dispensed with—a fire-brick deflector being introduced, involving the same principle. Supt. Scott was also sanguine that a saving of 50 per cent in the cost of fuel could be effected. Although the results are favorably spoken of in the late Report (14th A. R.) it does not appear that the end was attained, although the deflector which was largely introduced (costing $50.00) was regarded as economical, on account of enabling the Company to go back to the plain fire-box which, aside from possessing conditions favorable to combustion, was accessible for inspection and repairs. In the same year (1863), experiments were made with anthracite, an engine being built expressly therefor, with the latest improvements, but it was found that this fuel would not make steam freely enough on long, fast runs with heavy trains. Experiments are now making with an apparatus for bituminous coal, invented by J. T. Rich, of Philadelphia, who puts into the fire box a "dead plate," extending from side to side, sloping from a short distance beneath the door, and then turning down perpendicularly to the great-bars. Above is a fire-brick arch extending from the back well forward, around which the ascending flame must pass toward the front. Outside the door is a hopper, constantly supplied with coal, which it passes in, as that already in the fire-box works down to the dead plate. A fire being started on the great cokes, the coal on the dead-plate; and the heat is utilized by passing around the arch and through the flues. As the coke thus made itself burns away—its heat and gases, without smoke, passing through the flues—new coal constantly works down and undergoes the same process. The experiments thus far show there is no doubt that the process will result in almost entire freedom from smoke; but the practical question whether steam can be made fast enough, is not yet decided. Experiments are also making with coke already prepared; and it is deemed certain, should Mr. Rich's device not succeed, that coke, which can be obtained at morderate cost will be successfully used.—*Chicago Railway Review.*

UNIFORMITY OF LOCOMOTIVES.—The "American Railway Times" makes the following statement which was doubtless intended to be severe:

"Two years ago the Pa. R. managers determined to reduce their rolling stock down to some such simple system as we have indicated; and they have succeeded in reducing the varieties of engines down to 40, in a total equipment of 456 engines. This may be called a *reductio ad absurdum*.

Truly to your genuine nothing-if-not-critical Boston art, "Seneca cannot be too heavy, nor Plautus too light." The "Times" borrowed, and isolated, an expression in the "Review's" article, and chose to interpret it without reference to the full accompanying explanations. The 456 locomotives on the road are all referable to these three classes:

1. *Standard Passengers*, having 17x24 in. cylinders, and 5½ ft. drivers.

2. *Standard Freight*, 40-wheel, having 18x22 in. cylinders, and 4½ ft. drivers; and,

3. *Standard Shifting*, 6-wheel, having 15x18 in. cylinders, and 44 in. drivers.

Of the first class, there are two modifications—the Mountain Helper, having 18x24 in. cylinder, 5 ft. drivers, and large boiler; and a local and fast freight engine differing only in the diameter of the driver, 5 ft.

Of class 2 there is but one modification—a Mountain engine having 4 ft. drivers, and larger boiler. These are the only *classes* recognized; and of all these, the important working parts (castings) are interchangeable—such as driving-boxes, eccen-

tric stops, etc. Of *patterns* there are still well nigh as many as of manufactures; but these embrace only those which have been many years in use, and to have changed which to uniform standard or *pattern* would have necessitated their cutting-up long before this time of service had expired. The P. R. like most roads in the beginning, purchased engines of many different manufacturers; and as these wear out, their patterns disappear, so that within a few years there will be not only one invariable standard of construction, but of style.—*Cor. Chicago Railway Review.*

Improved Locomtive Alarm Bell.—There has been a recent trial on the Detroit and Milwaukie Railway, of an invention or device for ringing the locomotive bell continuously. The device consists of placing an ordinary bell, weighing about 100 lbs., on the front of the locomotive just over the cow-catcher. A rod attached to the eccentric shaft causes a clapper to strike the bell each turn of the driving-wheel. The bell is suspended loosely, and revolves from the force of the stroke it receives, so that all parts of its surface are equally exposed to wear.

The advantages of this arrangement are a continuous sound, slow or rapid in proportion to the speed of the engine, each revolution of the wheel producing a stroke of the bell. In case of accident the railway company can always prove that their bell was ringing according to law, that being the point most difficult to convince a jury, and the one which railways have the greatest difficulty in proving. Owing to the position in which this bell is placed—in front of the engine and about three feet from the ground—the sound can be distinctly heard about three miles in day time, and by night four miles or more, the ground and the continuous rail, both excellent conductors of sound, assisting in carrying the vibrations. The bell may also be rung, if necessary, by a cord from the foot board when the engine is at rest. Quite a number of these bells have been placed on the engines of the Detroit and Milwaukie Railway, and several other companies are giving them a trial. The inventor is Mr. Ben. Briscoe, the master mechanic of the Detroit and Milwaukie road, who has charge of the locomotive works of the company at Detroit, Michigan. He is one of the numerous graduates from the Baldwin Locomotive Works at Philadelphia.—*American Railway Times.*

Iron Cars.—The "Ironmonger" suggests the desirability of constructing trains wholly of iron. They might be so constructed of this material as certainly to offer greater power of resistance in case of collision, and this without materially augmenting their weight, whilst the danger from fire would be almost nil. With strong frames, properly braced, the sides might be covered with comparatively thin sheets of iron. Railway companies cannot certainly be expected, in view of the large intermediate outlay that would be involved in an entire change of rolling stock, to carry out at once the suggestion, but the transformation might be effected gradually, and all carriages hereafter constructed might be of iron. These iron cars would doubtless be more lasting, and, in the end, more economical. Our large iron manufacturers would do well to give this subject their attention.

The Shops of the Pacific Railway at Sacramento.—There are now 160 locomotives at the western end of the road—belonging to the Central Pacific Company—of which 29 can be accommodated at one time in the Sacramento round-house. Its front measures 611 ft.; its rear, 411 ft.; depth, 64 ft.; and height, 24 ft. Water for the engines is supplied from a side tower, called the oil-house, in the top of which is a tank containing 65,000 gallons of water, and below the same two stories for offices, and a cellar which holds seven great sheet-iron 1,000-gallon reservoir for oil, thus secured against fire.

The wood-working and car manufactory is another colossal building, 90x238 ft., of two colossal stories, with straining-beam truss roof, whereby the lower story is kept entirely free and unobstructed. There is also an L 45x90 ft. All the cars, including doors, windows, and upholstery, are made from California material, at a cost quite as low as that of the same articles imported. Numerous band-saws and other of the most complete modern wood-working machines may be seen at work.

The machine-shop is 100x205 ft., beautifully roofed, and filled with superb iron-working machinery adapted to railroad uses. This shop is intended to do all the iron-work of the road, but local repairing, for which shops have been built along the line—as at Rocklin, the "foot of the hill," where there is also a first-class granite round-house, and where two or three additional engines are in readiness to join the single one that does duty for fifty or sixty cars between Sacramento and that place. In the machine shop there are eleven pits, adapted for locomotive repairs, and a traveling bridge, by which locomotives can be picked up and lifted about like toys. The finest engine on the coast furnishes the power—a Corliss engine of 160 horse-power, built in Sacramento.

A blacksmith-shop 60 x 150 ft., to contain 30 forges and three steam-hammers, completes the list of buildings now erected.

Railways in New York.—The report of the State Engineer and Surveyor of Railroads for the last half year, gives the following statistics, which may be interesting to your readers:—

There are fifty-six different railways in operation in the State, the aggregate length of which is 3,053.95 miles, and which have been constructed and equipped at a cost of $208,185,782. Including roads contemplated, the whole number is eighty-one, with a length of 4, 567.99 miles. The oldest line is the Mohawk and Hudson, opened for travel a distance of seventeen miles, in 1831. The number of locomotives in use is 1,111; passenger cars, 1,163; baggage and mail cars, 362; freight cars, 17,934. During 1868, the number of passengers of all classes carried over the State was 18,434,300, and the amount of freight 11,961,692 tons. The cost of operating the roads was $15,250,716; the total payments, $48,274,476; and the total earnings, $49,377,790. The average rate of speed of ordinary passenger trains, including stoppages, was 18.55 miles per hour, while the average speed of express trains was 29.74 miles. The number of persons killed during the year was 302, and the number injured 358. Of these 104 were killed on the New York and Erie road, out of 2,194,348 passengers carried; on the Hudson River road 27 to 2,626,303; on the New Haven road 6 to 2,192,940; on the Har-

lem road 20 to 1,667,578; on the Long Island road 4 to 823,000; on the Staten Island road 1 to 349,853. The total amount recovered as damages for injuries to passengers, which the various companies were obliged to pay during the year, was $528,310. The Erie road paid $198,135; the Hudson River Company, $20,745; the New Haven road, $10.937; the Harlem road, $7,865; the New York Central, $72,944; the Buffalo and Erie road, $196,-405.

STEEL FIRE BOXES FOR LOCOMOTIVES.—At the late Master Mechanics' Convention, held at Pittsburgh, a committee was appointed to investigate and report on the question:

Are steel plates preferable to the best iron plates? and if so, does the difference in strength, safety and durability, justify the difference in cost? Also, how, in practical experience, does steel for furnaces compare with copper?

The committee reported much interesting testimony bearing on the subject, among others, the statement of an officer of the Northwestern R. R., who said:

Fifty-one locomotive fire-boxes, made of copper sheets half an inch thick, after thirty months' use, show marked indications of wear, and will probably have to be renewed in a short time. In some cases, after less than three years' service, the original half-inch sheets were reduced to less than one-eighth of an inch.

With reference to the application of steel for the purpose indicated, it was further stated by the same party, that:

On the Northwestern road, a locomotive has been run for eight years with a steel fire-box, which has thus far shown no signs of wear, although the coal and water used had proved extremely detrimental to the iron and copper fire-boxes previously used on the same division of the road.

On the Pennsylvania road, two locomotives fitted with steel furnaces in 1861, still remain intact, and two locomotives on the Baltimore and Ohio, furnished in like manner about the same time, show similar results. The committee unanimously and emphatically concluded "in favor of *homogeneous steel plates* for locomotive fire-boxes, at least of all those that burn bituminous coal; and that for boiler-plates for general construction, this material combines in a greater degree than any other, the requisites of durability, safety and economy."—*Chicago Railway Review.*

THE LOUISVILLE BRIDGE.—The great railway bridge on the Ohio river, at Louisville, Kentucky, will be ready for the passage of trains by the end of the present month. It is one of the finest and most important structures of the kind in the country. Its total cost when complete will be about one and one-half million of dollars. The length of the bridge is 5,200 ft., or nearly a mile. It is supported by twenty-five massive piers. The longest span is over the middle chute, and is 370 ft. At this point the bridge is 90¼ ft. above low water mark. There is a drawbridge over the canal of 114¼ ft. clear span. The grade from the Kentucky side is 82 ft. to the mile, the grade on the Indiana side being nearly 79 ft. A long and heavy embankment is necessary on the west side of the river, and that is nearly done. This bridge in addition to its railroad uses, is built for street cars and wagons, the supposition being that at certain times of the day—only one-eighth of the twenty-four hours—the railroad trains will occupy the bridge, leaving it free the rest of the time for ordinary travel. The estimates of this grand structure tell the story of what it is. The masonry cost $476,962, the iron superstructure $776,090, the whole amounting to $1,600,000.—*Polytechnic.*

LONG RAILWAY RUNNING.—In a recent article we referred to several instances of continuous railway "runs" of from 76 to 97¼ miles. We should have instanced the mail trains on the South-Eastern line, which, on the old line made 88 miles without stopping. *Via* Sevenoaks, the distance, we believe, is 75 miles. The engines have 16 in. (some of them 17 in.) cylinders, 22 in. stroke, and a single pair of 7 ft. driving wheels. The tenders contain 2,500 gallons of water. The usual train is from fourteen to eighteen carriages, and the average speed is from 40 to 45 miles an hour.—*Engineering.*

A REMARKABLE RAILROAD.—The most remarkable railroad in Germany and Europe is the new Black Forest road, which will be completed within four years. Between Hornberg and St. George, situated 2,870 feet above the level of the sea, and but four miles distant from Hornberg, the railroad ascends nearly 2,000 ft., and passes through 27,000 ft. of tunnels. Eleven thousand feet of the latter have been completed during the last two years. The truly cyclopean work on the road is progressing rapidly, and attracting thousands of visitors, who flock there from all parts of Southern Germany and Switzerland.—*Polytechnic.*

NEW BOOKS.

USEFUL INFORMATION FOR RAILWAY MEN. By W. G. HAMILTON, Engineer. D. Van Nostrand, 23 Murray street, New York.

We can fully indorse the following notice of this excellent work from "Engineering:"

This pocketbook, which in its original form and first edition was intended to serve no other purpose than a useful advertisement, has in its second issue developed into a *vade mecum*, which will be found more comprehensive and more serviceable than any work of the same kind in existence. The author, Mr. W. G. Hamilton, who is the manager of the Ramapo Wheel and Foundry Company, an establishment but recently established, yet now doing almost the largest business in chilled cast-iron wheels in the United States, contemplated originally the compilation of such a pocketbook from existing works of the same nature, and supplemented by his own notes and those of some other American engineers, as would be compressed into a small volume, that would carry its own recommendation as well as that of the business for which it served as an advertisement. This edition, which was a very large one, was gratuitously circulated throughout the United States, and led to so large a demand that the author determined upon producing a second edition, in which the Ramapo Foundry should make no obtrusive appearance. This is the issue under notice. It consists of 569 pages of very closely printed matter, in which are contained the bulk of Molesworth's, Hurst's and Nystrom's pocketbooks, copious compilations from the principal scientific writers, and, above all, a large compendium of United

States' railway practice. Of course a great deal of its contents have a special value for the American engineer, but these notes recommend themselves most strongly to ourselves, as representing the latest and best practice in the States. The index contains nearly a thousand items, many of which are illustrated sufficiently well to explain fully the subject to which they refer. The extent, cost and general particulars of American railways are given, the standard specification of rails upon the principal railways, the dimensions and description of rolling stock, the most recent improvements in locomotive practice, and epitomes of the financial management of railways. It would, of course, be impossible to convey an idea of the almost endless subjects upon which this little book touches, in each case profitably: it must suffice to recommend it, and to trust that it may be placed within the reach of English engineers.

THE POLYTECHNIC.—A Semi-monthly Paper devoted to the interests of Polytechnic and Scientific Schools, and a Record and Review of Civil, Mechanical and Mining Engineering, Natural Science and General College News, Troy, New York. MONTAGUE L. MARKS, Editor and Proprietor.

We can best state the character of this excellent publication by quoting from its prospectus:

"In adopting the name Polytechnic, our design has been two-fold, viz: First, to identify closely the title of our publication with that branch of knowledge, to the advancement of which it is especially devoted; and Secondly, by the general significance of the name as applicable to all Polytechnic and Scientific Schools, to demonstrate the design of the publisher to make the Polytechnic their common mouthpiece. By arrangements that we have made with some of the most able contributors to scientific periodicals in this country, and with other gentlemen of known ability, in each issue of the Polytechnic will be found valuable and original articles on subjects of general scientific interest. We shall devote a portion of our columns to items of current general scientific news selected and condensed from the best American and European papers and magazines. We have established a corps of correspondents at the various Polytechnic and Scientific Schools, and at the Scientific Departments of the principal Colleges, and from them we shall receive news on all topics of interest connected with their several localities."

We can assure our readers that the Polytechnic answers fully to this specification. And it is perhaps more elegantly "got up" than any other American scientific publication.

A TREATISE ON LAND SURVEYING, in theory and practice, giving the best methods of surveying and leveling, for statistical, estate and engineering purposes, together with full explanations of the construction, adjustment and use of theodolites, levels and other instruments required in the field and office work of surveying and leveling. By JOHN A. SMITH, Civil Engineer, London. Longmans, Green & Co., 1869. For sale by Van Nostrand, New York.

This work is well spoken of by the "Mechanics Magazine," which says:

While on the one hand the author has to travel a good deal in a well-worn path, it is open to him on the other to strike out a few fresh branches, without actually deviating from the main line. He has availed himself of this opening, and also treats the whole subject in that advanced style of mathematical and geometrical investigation which it is now able to bear. In former times, surveyors as a rule, were not educated men in any sense of the term, and a book similar to the one under notice, would not have been appreciated as it deserves to be. At the same time it must not be imagined that the author has plunged into the regions of abstruse mathematics. On the contrary, the formulæ and rules he gives are of a simple and practical nature, and may be easily mastered by any one possessed of that moderate amount of algebraical knowledge which all professional students acquire as a matter of course.

AN INTERNATIONAL FLOATING TUNNEL. By E. W. YOUNG, C. E. London, E. & F. Spon, 1869. For sale by Van Nostrand.

In the plan laid down by the author, it is proposed to construct between Dover and Cape Gris-Nez, a wrought-iron tunnel, in sections of from 200 to 300 ft., to float these into position and lower them into place at a certain depth below the surface of the water, where the joints being made good by divers, they would form one continuous tube across the Channel. Mr. Young thinks that the tube being buoyant it would have to be held down to the proper depth by means of anchor-chains attached to huge blocks of béton. The passage of trains would not materially affect the buoyancy, and the tube being placed below the surface would not be injured by the violence of the waves. Air would be supplied by a number of lighthouses placed along the line of the tube. Numerous sections and illustrations accompany Mr. Young's description, but we fear that his ideas will not receive the support of practical men. We think he underrates the difficulty of submerging and repairing such a tube as that he contemplates, and that he likewise insufficiently considers the terrible influence of the tidal currents on so large a mass.—*Scientific Opinion.*

SOCIETY OF ENGINEERS' TRANSACTIONS FOR 1868. —Spon, 48 Charing-cross. For sale by D. Van Nostrand. 23 Murray street, New York.

In the volume of this Society's Transactions just published, abundant proofs are evident of the increased care bestowed upon it by its editor. The volume contains nine papers, the three first of which by Dr. Edward Cullen, may be classed as one, belonging, as they do, to the same subject—improved communication between the Atlantic and Pacific, *via* the Isthmus of Darien. A paper on Engineering in India, by Mr. C. F. Danvers, and several minor contributions, brought the session nearly to a close, its two final meetings being occupied by Mr. Baldwin Latham's elaborate paper on Steam Cultivation, in which he deals as exhaustively with his subject as he did in his inaugural address, where sewage formed the *pièce de resistance*. To Mr. Latham and to Dr. Cullen, the volume owes the bulk of its handsome collection of finely executed lithographs.—*Engineering.*

A TEXT BOOK OF CHEMISTRY. A Modern and Systematic Explanation of the Elementary Principles of the Science, adapted to use in High Schools and Academies. By LE ROY C. COOLEY, A. M., etc. New York, Charles Scribner & Co., 1869.

THE PRINCIPLES OF PERSPECTIVE ILLUSTRATED IN A SERIES OF EXAMPLES. By HENRY D. HUMPHRIS. Descriptive Treatise and Atlas of Examples. London: Chapman & Hall. 1869.

Mr. Humphris, who is the son of an architect well known in his locality, has issued what is rather a series of examples to illustrate the principles of perspective than an elaborate essay on the science. They are drawn out of good size, and will be found very useful to art-masters, architectural students, and others. Mr. Humphris rightly points out that it would be useless to read the letter-press and look at the plates, and to imagine that a knowledge of perspectives is to be obtained by any such means; while to copy the figures line for line from the examples would be time as badly spent.—*The Builder.*

FIVE HUNDRED AND SEVEN MECHANICAL MOVEMENTS. By HENRY T. BROWN, Editor of the American Artisan. New York, Virtue & Yoston. For sale by Van Nostrand.

The public attention has been largely called to the book, but until every artisan, and especially every mechanician possesses it, we do not think too much can be said of its value. It consists simply of engravings and descriptions of 507 methods of transmitting or changing motion and power, in all the departments of mechanical construction, and running through every variation and combination of the mechanical powers, in gearing, escapements, water wheels, hydraulic machines and miscellaneous machinery. It contains a great many facts and a very little preaching, which is the best thing we can say of any book.

SPECTRUM ANALYSIS.—Six lectures delivered in 1868, before the Society of Apothecaries of London. By HENRY E. ROSCOE, B. A., Ph. D., F. R. S., Professor of Chemistry in Owen's College, Manchester. London, Macmillan & Co., 1869. For sale by Van Nostrand.

It was time that the general public should be made familiar with the grand facts and principles of spectroscopic analysis, and we therefore at the outset publicly thank Professor Roscoe for coming forward as the interpreter between the student of science and the educated members of the community. He has taken upon himself a task whose importance is only equaled by its difficulty, and it is only just to him to express our opinion that he has discharged a complex duty with ability and success. —*Scientific Opinion.*

A MANUAL OF THE HAND LATHE. Comprising concise directions for working metals of all kinds, ivory, bone and precious woods; dyeing, coloring and French polishing; inlaying by veneers, and various methods practiced to produce elaborate work with dispatch and at small expense. By EGBERT P. WATSON, late of the Scientific American, author of "The Modern Practice of American Machinists and Engineers." Illustrated by 78 engravings. Philadelphia, Henry Carey Baird, Industrial Publisher, 406 Walnut street. Price $1.50.

A POPULAR OUTLINE OF PERSPECTIVE OR GRAPHIC PROJECTION; PARALLEL, DIAGONAL, PANANGULAR, GRACEFUL. By THOMAS MORRIS, Architect. London: Simpkin, Marshall & Co. 1869.

THE STEPPING-STONE TO ARCHITECTURE. By T. MITCHELL. London, Longmans, Green & Co.

RAILWAY ECONOMY: USE OF COUNTER-PRESSURE STEAM IN THE LOCOMOTIVE ENGINE AS A BRAKE. By M. L. LE CHATELIER, Ingénieur-en-Chef des Mines. Translated from the author's manuscript by Lewis D. B. Gordon, F. R. S. E., Honorary Member of Institution of Engineers in Scotland. Edinburgh, Edmonston & Douglas.

THE ELEMENTS OF BUILDING, CONSTRUCTION AND ARCHITECTURAL DRAWING. By ELLIS A. DAVIDSON. London and New York, Cassell, Petter & Galpin. For sale by Van Nostrand.

MISCELLANEOUS.

SURFACE CONDENSER TUBES.—Rolled sheet copper is now quoted at about 80*l.* per ton, equal to a little more than 8¼d. per pound, although the nominal quotation *by the pound*, is 10d. Solid drawn copper condenser tubes of from ¼ in. to 1 in. in diameter, and sold only by the pound, are, on the average 1s. 10d. per pound, showing a charge of at least 1s. per pound, or more than the value of the metal itself, for the mere process of drawing—a process as tedious as it is trying to the metal. The usual thickness of these tubes is No. 18 of the Birmingham wire gauge, or one-twentieth of an inch. By the old process of drawing it would not be safe to make them much thinner on account of the risk of their splitting, the very process of drawing inducing longitudinal weakness, a weakness not found either lengthwise or widthwise of rolled copper sheets. Copper of No. 18 gauge weighs about 2 lbs. 6 ozs. per square foot, and as a foot of ¾ in. tube would require one-quarter of a square foot of plate, it works out that 2⅜ lbs. of copper would make four lineal feet of such tube, costing from 1s. 9d. to 2s. for metal, and selling for 4s. 4d. equal to a charge of from 7d. to 8d. per foot for drawing alone.

But copper of No. 18 gauge is only employed because of the risk of drawing it thinner. No. 23 gauge, of but half the thickness, and therefore of but half the weight, would be abundantly strong for a small surface condenser tube withstanding but 25 lbs. or, at the most 30 lbs. pressure per square inch, whereas its full strength, if sound, should be equal to an internal pressure of at least a ton per square inch. Yet with No. 18 tubes, which *ought* to withstand two tons per square inch, the highest test pressure adopted by some of our leading marine engineers is but 60 lbs. per square inch. And this is enough, being at least twice what the tube ever has to withstand. If the tubes could be made of half the thickness, that is, No. 23 of the Birmingham wire gauge, they would conduct heat even more rapidly than when of No. 18 gauge, and thus even less condensing surface, and, therefore, even less than half the weight of tubing would be requisite.

But the cost of drawing, viz: 7d. to 8d. per foot, is in itself enormous. The tube machine exhibited at Messrs. Robert Stephenson & Co.'s works during the Newcastle meeting of the Mechanical Engineers, and now again working, we believe, at Messrs. George England & Co.'s works at Hatcham, can convert sheet metal into tubes at a cost, for manufacture, not exceeding half a farthing per foot. The joint made is a mechanical joint only, but it has been tested to more than three times the proof test we have named, and that without the slighest

suspicion of a leak. With the success, already reasonably certain, of this mode of making tubes, it will be matter of surprise, if ¾ in. condenser tubes, now costing 13 d. per foot, are not brought down to 5 d. No combination of the simplest mechanical movements has for a long time been announced with any claim to the genuine merits of the American machine.—*Engineering.*

TELEGRAPH ENTERPRISE.—The disposition of the public to pay attention to telegraphic enterprise is attended by the usual result of a multiplicity of projects being hurried out, but the events of 1866 are not yet sufficiently remote to admit of the prospect of danger. The French Atlantic cable being only a few weeks old, a new one from Ireland to Nova Scotia of a light description, to cost £450,000, is now talked of, which is to do the work of the existing cables at half-price. If the capital could be found and the line successfully laid, the shareholders would probably be informed within a month that a fresh one of still lighter construction would be proposed, which, at a further reduction of 50 per cent in the tariff, would still be expected to prove highly remunerative. That the progress of electrical science will ultimately cause the cables of the present day to appear cumbrous can hardly be doubted, but much further experience will be necessary before any very costly experiments in that direction can be ventured upon. It is affirmed on good authority that during the last eighteen years there have been 8,000 miles of light cable laid, some covered with light wire, two consisting of india-rubber core alone, and others protected with hemp and other substances, but that no line of this description has been found to last longer than one year, while in some cases the period has been a few weeks only. All the cables now in working order are of the strong and heavy form, and there seems no example of any kind that can be cited to justify the adoption of the light principle.—*London Times.*

THE OXYHYDROGEN LIGHT scheme now has taken a definite shape in Paris. A company has been formed, the capital necessary has been raised, and application has been made for permission to lay down pipes to carry oxygen and hydrogen over about a fourth of the city. It is not very likely that the permission will be granted, and the promoters will have to confine themselves to supplying individuals with compressed gases, as was originally proposed. We have published the patented processes by which M. Tessié du Motay obtains the oxygen and hydrogen which he proposes to distribute over Parris, at a cost so low that the oxyhydrogen light is promised much cheaper than common gas light; but ingenious and relatively cheap as they undoubtedly are, it is impossible to believe that the service can be made so inexpensive as to supersede coal gas. The prospectus of the company enlarges upon the cheapness and purity of the light, the complete combustion, and the absence of all deleterious matters in the products of the combination; but is quite silent as to the danger of introducing into a house two gases not possessing any smell, and which, consequently, may escape without observation, and the mixture of which forms an explosive compound of far greater power than any mixture of coal gas and air. To any danger of this kind, Continental engineers appear to shut their eyes. We saw, a short time ago, a patent taken out in Belgium for making a mixture of coal gas and air, storing it in gas holders and distributing it over the city of Brussels for heating purposes. The engineering details given, showed a complete knowledge of the subject of the manufacture and distribution of gas, but there seemed to be no recognition of the risk, imminent enough of blowing up the whole concern. A consideration of this kind, some years ago, stood in the way of a scheme of the kind projected for Birmingham, and will, no doubt, prevent the Oxyhydrogen Light Company from getting permisssion to lay down their pipes over Paris.—*Jour. Franklin Institute.*

TINTS TO EXPRESS BUILDING MATERIALS.—The following are the conventional tints employed in England, and with little exception, elsewhere among engineers and architects:

Materials.	Color.
Brickwork to be executed (in plans and section..	Crimson lake.
Brickwork in elevations..	Crimson lake mixed with burnt sienna or Venetian red.
The lighter woods, such as fir.....	Raw sienna.
Oak or teak.....	Vandyke brown.
Granite	Pale Indian ink.
Stone generally.....	Yellow ochre or pale sepia.
Concrete works.....	Sepia with darker markings.
Wrought iron	Indigo.
Cast iron	Payne's grey or neutral tint.
Steel.....	Pale indigo tinged with lake.
Brass	Gamboge or Roman ochre.
Lead	Pale Indian ink tinged with indigo.
Clay or earth.....	Burnt umber,
Slate.....	Indigo and lake.

THOMSON'S ROAD STEAMERS.—The Oriental Coal Company (Limited), into whose hands the extensive coal mines in the island of Labuan have passed, are now working them successfully. In anticipation of a great increase in the demand for coal in the China seas on the opening of the Suez Canal, it has been decided to supply coal at the fine harbor of Victoria, which admits and shelters vessels of the largest size at all times of the tides and at all seasons, instead of at Coal Point, as at present, where steamers can take in coal only in comparatively fine weather. The distance from the mines to Victoria harbor, where the Governor's residence and all the public buildings are situated, is about nine miles, and the coal is to be transported by means of the patent road steamers, with india-rubber tyres, of Mr. R. W. Thomson, C. E., of Edinburgh. Two of these powerful engines and sixteen wagons, to carry six tons each, are already completed, and will be shipped direct to Labuan in the company's new screw collier "the William Miller." These road steamers appear to be exciting great interest all over the world. The Government of India have just ordered to be despatched overland the first engine for a regular service, which they intend establishing on the Grand Trunk Road, for

the transport of troops, Government stores, and general merchandise, in lieu of the miserably slow and costly bullock-trains which now creep along that fine road. The road steamers will, it is said, run five or six miles per hour at far less cost than the bullock hackeries, which cannot keep up a third of that speed.

To estimate the force of the tides, all that is necessary is the consideration that the attraction of the sun and moon (principally of the latter), acting in opposition to terrestrial gravitation, elevates the surface of a large portion of the ocean, nearly twice in 24 hours, to the mean height of about two feet. The extent of surface thus raised may be set down at 100,000,000 square miles, or one-half of the surface of the earth, taking this at 200,000,000 of square miles, of which the ocean occupies about three-fourths, or 150,000,000. Every square mile of water two feet thick contains nearly 60,000,000 cubic feet, or 3,840,000,000 pounds of water, and this, multiplied by 100,000,000, the number of square miles affected by the tide, gives the enormous number of 768,000,000,000,000,000 foot pounds exerted every twelve and a-half hours, or 750 minutes, which gives, per minute, a power of 100,000,000,000,000,000 foot pounds. Dividing this by 33,000, to reduce it to horse-power, we obtain nearly 3,000,000,000,000 horse-power as the total power of the tide-wave over the whole surface of the earth.—*The Engineer.*

Zinc Sheathing for Ships.—There is nothing novel in the idea of preventing the oxidation of iron ships by the use of zinc. Several modes of applying the zinc have been suggested by various inventive minds, but, for some reason or other, shipowners still rely on paint to preserve their ships, and do not seem to have faith in the protective power of electrical action. The latest invention for the protection of iron ships by this means is that of MM. Demance and Bertin, who distribute about the inner side of the shell, tubular reservoirs, made of zinc, which are riveted to the plates, to place the metal in perfect communication with the iron hull. These reservoirs are charged with sea water, which is changed every day. Bands of zinc carried in all directions over the inner side of the hull connect the various reservoirs, and strips are here and there brought to the outer side, and made to communicate with the sea. We need not here explain the action which takes place. If the authors can be relied upon, the success obtained is perfect. Experimental boats kept in very salt water for a year, they say, do not exhibit a trace of oxidation in any part.—*Mech. Magazine.*

Apprentice system in the shops of the Pennsylvania Railway.—Of the 4,087 names on the rolls of the Motive Power and Mach. Dept. at the beginning of the year, 114 are designated as "apprentices." If to these we were to add such as among the one thousand skilled workmen have risen to that class through apprenticeship, the number would be increased perhaps three-fold or more. Boys are taken at seventeen years of age,—if possible on their birth-day,—and are indentured for four years, receiving 75 cents per day for two years, 90 cents the third year, and $1,00 the fourth. If during this period of apprenticeship their conduct and service has been satisfactory, they receive $124 bonus on the cancellation of the indenture. They afterwards receive, as skilled workmen, from $1,50 to $2,90 per day. Work begins in the locomotive shops with vice-filing, from which the apprentice passes, successively to machine work, running tools, and setting up engines; in carpentry, freight is followed by passenger car work. The result is, in the case of a boy adapted to the work, not only skill in the performance of the different operations involved in car or locomotive building, but a discipline, a system, which admirably fit him to take charge of work; and, accordingly, we find that many of the best foremen, to whose inventiveness and resources the Company owes much every year, are from the class of apprentices who have received technical education in the shops. The system works satisfactorily in every respect. It is sometimes the case that the apprentice, now become an expert, seeks service elsewhere at the end of his term; but with rare exceptions, such return in the course of a year or two.—*Chicago Railway Review.*

The Albany Iron Works' Axles.—The car axles made by Messrs. Erastus Corning & Co., and which have deservedly attained to a great celebrity on the many railways where they are used, are made as follows: Selected scrap or selected puddle-bar made from charcoal (20 per cent) and best anthracite pig, is rolled into 2 by 1 in. bars. These bars are made into a pile 8 in. square with $\frac{3}{4}$ in. top and bottom made of finished bars. The pile is reheated and rolled to 7 in. round, and this is reheated, forged down and finished under the trip hammer. It is not surprising that these axles never break in service.

Our Index.—Those who have occasion to refer to the back volumes of Engineering periodicals, will admit that, as a rule, the easiest way to find any given article is to begin at page 1 and search for it. Index making has been deemed merely clerical work, as if no professional knowledge were necessary in arranging subjects under the proper headings. We believe the index presented herewith will be found convenient and complete.

The India Rubber Manufacture.—The *North American Review* states that there are now in America and Europe, more than a hundred and fifty manufactories of india-rubber articles, employing from four to five hundred operatives each, and consuming more than ten millions of pounds of gum per annum. The business, too, is considered to be still in its infancy. Certainly it is increasing. Nevertheless there is no possibility of the demand exceeding the supply. The belt of land around the globe, five hundred miles north and five hundred miles south of the equator, abounds in trees producing the gum; and they can be tapped, it is said, for twenty successive seasons. Forty-three thousand of these trees have been counted in a tract of country thirty miles long and eight wide. Each tree yields an average of three tablespoonfuls of sap daily, but the trees are so close together that one man can gather the sap of 80 in a day.

Lighthouses.—According to the *Scientific Review*, a French writer calculated that, at the commencement of 1867, there existed in the world 3814 lighthouses, or phares, of more or less importance, viz: 1785 on the coast of Europe; 674 on those of America; 162 in Asia; 100 in Oceania; and 93 in Africa. As regards Europe, the best lighted coasts are those of Belgium, France following immediately

afterwards. Then come, in order in which their names are given, Holland, England, Spain, Prussia, Itlay, Sweden and Norway, Portugal, Denmark, Austria, Turkey, Greece, and finally Russia. Besides Europe, the best lighted coasts are those of the United States, which have one light for every twenty miles, whilst the Brazilian coast has only one for every 87 miles. Of the 2814 in existence at the commencement of 1867, about 2300 had been established since 1830, while the power of the greater part of those existing prior to 1830 has increased.

THE STEAMSHIP ADRIATIC.—This fine American built vessel has been purchased by Messrs. Bates & Co., of Liverpool, for the purpose of being converted into a sailing ship. The Adriatic was originally one of the Collins' line of mail steamers, and ran for a time between Liverpool and New York. In 1861 she was purchased by the Atlantic Royal Mail Company, and in the month of April of that year was placed on their line between Galway and New York. Towards the end of 1861 she was chartered by the government to convey troops to Canada, and on her return she was again fitted up as a passenger ship and placed on the Galway line until the whole undertaking collapsed, when she was taken round to Southampton Docks, where she has remained unemployed until the present time. The Adriatic is one of the largest paddle steamers ever built, and her history has been anything but an uneventful one. She was built and fitted up at enormous expense, and now, after lying idle for six years, she has changed hands at very little more than her repairs and fittings have cost. She will make a magnificent sailing vessel, although not adapted for the Atlantic steam trade.

OROIDE is the name of a new metallic composition which resembles gold very closely. It was invented in France, and is made by means of 100 parts of copper; 17 parts of tin or zinc; 6 parts of magnesia; 3-6 parts of sal-ammoniac; 1-8 parts of calcined lime and 9 parts of cream of tartar. The copper is at first melted alone; then magnesia; sal-ammoniac; lime and cream tartar are added in small portions under continual stirring. This takes half an hour, then tin or zinc is added, and mixed with the copper by stirring. The crucible in which these operations are prepared, is then covered up and kept in the fire for 35 minutes. The product is cast into bars, which can be rolled, hammered and pressed. It is difficult to distinguish this composition from gold.—*Steirm. Industrie u. Handelsblatt.*

THE VACUUM METHOD OF MAKING ICE.—An ice and cold producing machine has been invented by Herr Franz Windhausen Brunswick. The action of the machine is based on the principle of producing cold by the expansion of atmospheric air, which is accomplished by means of mechanical power. The machines require no chemicals, nothing being used in them but water and atmospheric air. They may be wrought by steam, water, or wind, and they produce from 100 to 1,000 lbs. of ice per hour, according to size, at a cost of from 2d. to 5d. per 100 lbs.; this difference resulting from the varying prices of fuel and the mode of working chosen. One of their uses is to cool rooms, cellars, theaters, hospitals, compartments of ships, etc.—*Builder.*

THE SMOKE NUISANCE.—Dr. Angus Smith has experimented on smoke of various degrees of blackness and brownness, and he shows that the difficulty of consuming smoke does not commonly arise from a deficiency of air in the furnace, but from the fact that a rapid draught often fails to allow time for proper combustion. It is now certain that the black smoke prohibited by Act of Parliament contains carbonic oxide, one of the most poisonous of gases. Carbonic oxide is only detected in smoke of the illegal density, and when we find that this black smoke is really an expensive article to produce we seem to be furnished with every reason why such a nuisance should be prohibited.

THE BERMUDA FLOATING DOCK.—Although predictions of disaster as to her voyage out were plentiful, the great Bermuda dock has arrived safely at the island. The passage was made, it would appear, under favorable circumstances. The absence of suitable dock accommodation at Bermuda has long been felt, and now that this want has been so well supplied, war ships on the North American and West Indian stations can be overhauled and repaired, instead of being sent home for those purposes.

THE WIRE TRAMWAY COMPANY have contracts at present in execution in France for about 25 miles of wire tramway, all for beet sugar makers. Mr. Hodgson, the inventor, is at present engaged constructing the line for the Pestarena Company in the Alps; besides this, the company have contracts in Spain, Sweden and Austria, and are shipping lines to New Zealand and Peru. Several short lines are in course of construction in England, and the difficulty of obtaining right of way is alone preventing them doing a large business in this country.

SHAPE OF SCREW TAPS.—Mr. Wm. A. Sweet of Syracuse, informs us, referring to an article we translated on page 976, from a German Magazine that he commenced a lathe for the same purpose in 1864, that he then learned that Messrs. Wm. Sellers & Co. had the same idea, and that he has quite recently seen at the works of Messrs Kenyon & Co., Steubenville, O., a lathe for cutting taps on this principle, made thirty years ago, and in use ever since. In this lathe, however, the groove has a curved bottom which will not clog—a great improvement on the German idea.

THE LARGEST SPAN of any truss bridge in the United States is that of the great bridge across the Ohio river at Louisville, which is destined to connect the Kentucky and Indiana shores. The bridge itself will be, when finished (and the engineer in charge expects to turn over his contract for the building some time in November), one of the most splendid structures of the kind in this or any other country. This last span covers three hundred and seventy feet, and is a marvel of engineering skill.—*Engineer.*

BRITISH STEAM VESSELS.—An official return shows that down to the 1st of January, 1869, there had been registered at the ports of the United Kingdom 2,916 steam vessels, their aggregate registered tonnage being 904,191 tons, and their gross tonnage 1,341,106 tons. The date of build ranges from 1823 to 1868; the oldest is Ann and Jane, of Newcastle, of 27 tons.